Production of juice concentrates and fruit powders from cactus pear for food colouring

Although cactus pear \textit{(Opuntia ficus-indica (Linn.) Mill.)} fruit meets all requirements for food colouring purposes, no attempt has been made so far to exploit its potential. The feasibility of processing cactus pear juice into concentrates and fruit powders was demonstrated in a study conducted by researchers at Institute of Food Technology, Hohenheim University, Stuttgart, Germany. Their work was aimed both at improvement and extension of a previously developed process for the production of cactus pear juice. The total yield was increased by 10\% through processing whole instead of peeled fruits and by further optimization of pulp enzymation. As an alternative to HTST (high temperature short time) pasteurization, cross-flow microfiltration was applied for non-thermal cactus pear juice preservation. Juice concentrates and fruit powders were produced by rotary evaporation and freeze drying at laboratory scale and compared to products obtained at pilot plant-scale applying a three-stage column evaporator and spray drying, respectively. To monitor process-related quality changes, the resulting products were characterised in terms of colour and selected quality parameters. For both juice concentrates and fruit powders, initial colour characteristics were retained. In addition to betanin isomerisation, C\(_{11}\)-epimerisation of proline-betaxanthin was demonstrated to be a valuable indicator of the respective heat treatment applied. Whereas no adverse reactions were observed during juice production, non-enzymatic browning and 5-hydroxymethylfurfural formation were found after concentration at pilot plant-scale and freeze drying, respectively.

The use of fruit powders for colouring dessert preparations, fruit or cereals bars, instant dishes and chocolates opens new fields of application for cactus pear fruits. Thus, cactus pear is considered a new valuable source of water-soluble, yellow-orange colour preparations. In contrast to single-strength juice, concentrates and powders are easier to handle during transportation and storage and also open further fields of application that may promote cactus pear fruit processing at industrial scale in the future [Mobhammer Markus R, Stintzing Florian C and Carle Reinhold, Evaluation of different methods for the production of juice concentrates and fruit powders from cactus pear, \textit{Innov Food Sci Emerg Technol}, 2006, 7(4), 275-287].

Dyeing cotton, wool and silk with \textit{Gulzuba}

Cotton rose, \textit{Hibiscus mutabilis Linn.} (Local name — \textit{Gulzuba}) belongs to family Malvaceae, produces natural dye which has been used for dyeing textiles. The most notable characteristic of this flowering shrub is that flowers of 3 distinct colours appear on the bush simultaneously, as the blooms’ colour cycle is independent of one another. Single and double flowered varieties are available, both having quite large blossoms that are 8-13 cm across. Aqueous extract of \textit{gulzuba} flowers yield shades with good fastness properties. The dye has good scope in the commercial dyeing of cotton, silk for garment industry and wool yarn for carpet industry. In a study conducted by researchers at Indian Institute of Technology, Kanpur, India dyeing with \textit{gulzuba} has been shown to give good dyeing results. Pretreatment with 2-4\% metal mordants and keeping M:L ratio as 1:40 for the weight of the fabric to plant extract is optimum showing very good fastness properties for cotton, silk and wool dyed fabrics. Preparation of dry powder is in progress so that this can be available as a cheap source of natural dye having good shelf-life [Shanker Rakhi and Vankar Padma S, Dyeing cotton, wool and silk with \textit{Hibiscus mutabilis} (Gulzuba), \textit{Dyes Pigments}, 2007, 74 (2), 464-469].
Dyeing of cationised cotton with lac

Conventional wisdom leads to the belief that natural dyes are eco-friendly than their synthetic counterparts. Recently, the potentiality of using natural dyes in textile coloration as anti-UV and anti-microbial has been reported. Lac dye (C.I. Natural Red 25; C.I. 75450) is obtained from the dried bodies of an insect, Coccus laccae (Laccifer lacca Kerr), found growing on the twigs of certain tree native to Southeast Asia. The use of lac dye in the dyeing of silk and leather seems to have been known to the Chinese some 4000 years ago. Lac is a mixture of at least five closely related lacciac acids, which are water-soluble red dyes of anthraquinoid type structure.

The dyeing of cationised cotton fabrics with lac natural dye has been studied by researchers at Textile Research Division, National Research Centre, Cairo, Egypt using both conventional and ultrasonic techniques. The effects of dye bath pH, salt concentration, ultrasonic power, dyeing time and temperature were studied and the resulting shades obtained by dyeing with ultrasonic and conventional techniques were compared. Colour strength values obtained were found to be higher with ultrasonic than with conventional heating. The results of fastness properties of the dyed fabrics were fair to good. Dyeing kinetics of cationised cotton fibre with lac dye using conventional and ultrasonic conditions were compared. The values of dyeing rate constant, half-time of dyeing and standard affinity and ultrasonic efficiency have been calculated and discussed.

Ultrasonic proved effectiveness in dye-uptake of cationised cotton fabric with lac dye and the enhanced effect after equilibrium dyeing was about 66.5% more than the conventional heating. This technique in addition to its advantage of saving the processing time and energy offers better environmental impact as it helps to obtain higher dye-uptake and also efficient dye bath reuse [Kamel MM, El-Shishtawy Reda M, Youssef BM and Mashaly H, Ultrasonic assisted dyeing. IV. Dyeing of cationised cotton with lac natural dye, Dyes Pigments, 2007, 73(3), 279-284].

Enzymatic natural dyeing of cotton and silk fabrics without metal mordants

Enzymes have enjoyed considerable use for many years in the textile industry e.g. amylases are used in desizing, cellulases in denim finishing and bio-polishing of cellulosic fibres, proteases in leather, silk and wool processing and pectinases-amyrase, lipase and diasterase are used in the bio-preparation of cotton fabrics. The scientists of Facility for Ecological and Analytical Testing, Indian Institute of Technology, Kanpur, Uttar Pradesh, India had used enzymes for dyeing cotton with two natural dyes namely-tectona and catechu and found encouraging results. Most of the enzymes used are derived from fungal sources such as amylase (Aspergillus niger), protease (A. oryzae) and lipase (A. niger). Furthermore, since no reference could be found pertaining to the use of an enzyme in conjunction with tannic acid for the improvement of the fastness of these natural dyes on cotton and silk fabrics, the researchers attempted to use tannic acid-enzyme interaction strategy in two ways. Two step ultrasonic dyeing of cotton and silk fabrics with natural dyes obtained from, Arjuna, Terminalia arjuna (Roxb.) Wight & Arn., Pomegranate, Punica granatum Linn. and Indian Rhubarb, Rheum emodi Wall. ex Meissn. have been developed in which an enzyme is complexed with tannic acid first as a pretreatment. This was found to be comparable with one step simultaneous dyeing. The effectiveness of three enzymes-protease-amylase, diasterase and lipase was determined. The enzymatic treatment gave cotton and silk fabrics rapid dye adsorption kinetics and total higher adsorption than untreated samples for all the three dyes. The CIELab values also showed improvement by enzymatic treatment. The tannic acid-enzyme-dye combination method offers an environmentally benign alternative, ‘soft chemistry’ to the metal mordanted natural dyeing [Vankar Padma S, Shanker Rakhi and Verma Avani, Enzymatic natural dyeing of cotton and silk fabrics without metal mordants, J Clean Prod, 2007, 15(15), 1441-1450].
The scientist at Italy developed an analytical technique based on GC-MS (Gas chromatography and mass spectrometry), which allows not only to determine the main flavonoid chromophores in textile and tapestry samples in order to assess the original dye source, but also to characterize degradation products which may be produced after ageing. The most common yellow dyes were extracted from weld (Reseda luteola Linn.), young fustic (Cotinus coggygria Scop.), dyer’s broom (Genista tinctoria Linn.), sawwort (Serratula tinctoria Linn.) and the berries of some species of Rhamnus Linn. Specifically, a new procedure for the extraction and derivatisation of flavonoids with N,O-bis(trimethylsilyl)trifluoroacetamide has been developed in order to make them detectable in complex mixtures by GC-MS analysis. The procedure was tested by analysing dyed wool reference specimens, not aged and aged in a Solar Box.

The method is based on the solvent extraction of flavonoids from raw plant materials, aged and not aged alum-mordanted wool dyed specimens; subsequently, flavonoids are derivatised with N,O-bis(trimethylsilyl)trifluoroacetamide and analysed by GC-MS. The method easily allows the identification of a dyestuff by the detection of the molecular markers apigenin, luteolin, genistein, morin, maclurin, together with 4-hydroxybenzoic acid, 3,4-dihydroxybenzoic acid, 2,4-dihydroxybenzoic acid and 2,4,6-trihydroxybenzoic acid, which survive in aged textiles. Two photo-oxidative degradation pathways for colour fading, one involving the mordant metallic ion and the other the light as a catalyst, are suggested [Colombini Maria Perla, Andreotti Alessia, Baraldi Cecilia, Degano Ilaria and Lucejko Jeannette Jacqueline, Colour fading in textiles: A model study on the decomposition of natural dyes, Microchem J, 2007, 85(1), 174-182].

### UV-Protective Properties of Natural Dye

The over-exposure to UVR would cause sunburn, skin damage and an increased risk of developing skin cancer. Especially, high levels of exposure in childhood have been associated with greater proneness to develop skin cancer. If all current exposure to solar UVR could be significantly reduced, the incidence of skin cancer would eventually decrease significantly. Although protecting the skin with clothing is a convenient and valid method, common clothing, including cotton, silk, wool and synthetic fabrics, is not effective for UVR protection because of the high UV ray transmittance of the fabrics. In the past decade little attention has been given to the functions of the natural dyes as UV-protector. The scientists of China investigated UV-protection properties of the cotton and silk dyed by natural dyes. The ultraviolet protective properties of the fabrics dyed by Rheum sp. and Lithospermum erythrorhizon Siebold & Zucc. were investigated. Experimental results revealed that the fabrics dyed with natural dyes had good ultraviolet protective properties. They could absorb about 80% of the ultraviolet rays. It was demonstrated that the UV-protective effect was strongly dependent on the absorption characteristics of natural dyes for UVR. Natural dyes such as Rheum and L. erythrorhizon had comparable UV-absorption performance to the common UV-absorber, benzophenone [Feng XX, Zhang LL, Chen JY and Zhang JC, New insights into solar UV-protective properties of natural dye, J Clean Prod, 2007, 15(4), 366-372].

### Pomegranate Fruits Pigment as Sensitizer in Solid-State Solar Cells

Several natural pigments have been utilized as sensitizers in photovoltaic cells due to their capability of injection of electron from excited pigments to the conduction band of anchored material. The scientists at Sri Lanka have fabricated a solid-state solar cell using juice extracted from pomegranate fruits (rich with cyanin and derivatives) as the light-harvesting analog in a dye sensitized solid-state photovoltaic cell. Strong chelation of flavylum with TiO₂ changes it to quinonoidal form. The juice extracted from pomegranate fruits containing cyanin (flavylum) is utilized. A higher incident photon to current conversion efficiency is observed in solid-state TiO₂-pomegranate pigment-CuI solar cell compared to that of the cells (TiO₂-dye-CuI type) sensitized with other natural pigments [Sirimanne PM, Seneviratnna MK, Premalal EVA, Pitigala PKDDP, Sivakumar V and Tennakone K, Utilization of natural pigment extracted from pomegranate fruits as sensitizer in solid-state solar cells, J Photochem Photobiol A: Chemistry, 2006, 177(2-3), 324-327].
Dyeing of wool and silk with pomegranate

Pomegranate fruit (*Punica granatum* Linn.) is appreciated for its cool refreshing juice and medicinal properties. The fruit rind is red to brown in colour and used for textile dyeing. The application of dye obtained from pomegranate fruit rind on wool and silk fabric in the presence and absence of environment-friendly mordanting agents has been studied by researchers at Institute of Jute Technology, Kolkata, Department of Chemistry, Jadavpur University, Kolkata and Visva Bharati University, Santiniketan, India. The dyeing of silk and wool with pomegranate solution is found to be effectively accomplished at pH 4.0. Pre- and post-mordanting employing ferrous sulphate and aluminium sulphate improve the colour uptake, light fastness and colour retention on repeated washing. The use of ferrous sulphate and aluminium sulphates as mordanting agents alter the tone of dyed substrates towards grey and yellow, respectively. The use of such mordants, however, does not improve wash fastness property of dyed substrates [Das Debasish, Bhattacharya Subhash Chandra and Maulik Sankar Ray, Dyeing of wool and silk with *Punica granatum*, *Indian J Fibre Text Res*, 2006, 31 (4), 559-564].

**Antimicrobial activity of cotton fabric dyed with onion**

Onion (*Allium cepa* Linn.) has been extracted to obtain colour compound for dyeing cotton fabric and the antimicrobial property of dyed fabric was studied by researchers of Taiwan, R China. The fabric was first desiccated with ethanol and then pretreated with low-temperature microwave plasma for 4 seconds with oxygen pressure of 0.2 Torr and power of 800 W. Thereafter, the plasma-treated samples were grafted for 10, 30, 60 minutes at 70°C with onion skin and onion pulp extractions. The best inhibition zone of anti *Staphylococcus aureus* of both onion skin and onion pulp show anti *S. aureus* ability even after 5 times test washing, but both the samples lost their anti *S. aureus* property with 60 minutes grafting. The FTIR-ATR (Fourier transform infrared attenuated total reflection) spectrum of dyed cotton fabric shows flavonoids’ functional peak at 1624/cm of onion skin that provides cotton fabric brown colour with wash fastness rating of 4 [Chen Chonyu and Chang Wen-Ya, Antimicrobial activity of cotton fabric pretreated by microwave plasma and dyed with onion skin and onion pulp extractions, *Indian J Fibre Text Res*, 2007, 32 (1), 122-125].

**Effect of chitosan treatment on turmeric dyed cotton yarn**

Cotton yarn has been coated with different concentrations of chitosan solution and then dyed with turmeric to study their effects on yarn properties by researchers of India. It is observed that the tensile strength, flexural rigidity and shear strength increase with the increase in chitosan concentration. However, the coefficient of friction decreases with the increase in chitosan concentration. Cotton yarn coated with chitosan is found to be darker compared to uncoated yarn while dyeing for the same shade percentage. The dyed yarn coated with chitosan exhibits excellent activity against bacteria, such as *Escherichia coli* and *Staphylococcus aureus* [Kavitha T, Padmashwini R, Swarna A, Giri Dev VR, Neelakandan R and Senthil Kumar M, Effect of chitosan treatment on the properties of turmeric dyed cotton yarn, *Indian J Fibre Text Res*, 2007, 32(1), 53-56].
Lac dyeing on cotton pretreated with chitosan

Lac dye is used extensively as a natural food additive and in cosmetics, as well as a colorant for silk and cotton dyeings. However, lac dye has a low affinity for cotton because cotton does not have any cationic sites for the attachment. An alternative way to overcome this problem is the pretreatment of cotton with cationic agents. It was found that the cationised cotton which was dyed with lac dye exhibited a good colour yield and wet fastness properties even without mordanting. In addition, poly(ethyleneimine) (PEI) has been used as a cationic agent in cotton dyeing with lac dye. It was found that PEI increased the dye adsorbed on cotton and also decreased the dye desorption from the fibre.

Chitosan is a deacetylated derivative of chitin, a natural polymer found in the shell of crabs and shrimps. It has also been used to treat cotton in lac dyeing processes. It was found that chitosan enhanced the uptake of lac dye and increased lac dye sorption on cotton. Researchers of Thailand and Australia investigated the adsorption and thermodynamics of lac dyeing of cotton pretreated with chitosan compared with untreated cotton. The effect of sodium chloride (NaCl) on the dyeing process with, and without, pH control was also studied.

Adsorption and thermodynamic studies of lac dyeing on cotton pretreated with chitosan were investigated under dyeing conditions of pH 3.0, a material to liquor ratio of 1:100 and a contact time of 3 hours. The pretreatment of cotton with a 0.3% aqueous (v/v) solution of chitosan provided a significant enhancement of dye uptake onto the cotton and also a decrease in the dye desorbed from the cotton compared with the results in the absence of chitosan or on lac dyeing in the presence of NaCl. In addition, sodium chloride had no effect on the adsorption of lac dye on cotton at pH 2.5, 3.0 and 3.5. It indicated that hydrogen ions (H+) play a more important role than sodium ions (Na+) in the dyeing process. Pretreatment of cotton with chitosan is thus an alternative way to create cationic sites on cotton and subsequently to increase the affinity between lac dye and the fibre. The results from this study would help to underpin future improved practical applications of lac dyeing of cotton [Rattanaphani Saowanee, Chairat Montra, Bremner John B and Rattanaphani Vichitr, An adsorption and thermodynamic study of lac dyeing on cotton pretreated with chitosan, Dyes Pigments, 2007, 72(1), 88-96].

Ultrasonic dyeing of cotton fabric with Eclipta alba (Linn.) Hassk.

It is reported that ultrasound energy has great potential in industrial processes as it offers reduction in cost, time, energy and effluents. The dyeing of cotton fabric using Eclipta alba (Linn.) Hassk. as natural dye has been studied at Indian Institute of Technology, Kanpur, India in both conventional and sonicator methods. The effects of dyeing show higher colour strength values obtained by the latter. Dyeing kinetics of cotton fabrics were compared for both the methods. The time/dye uptake reveals the enhanced dye uptake showing sonicator efficiency. The results of fastness properties of the dyed fabrics were fair to good. It is hoped that Eclipta dye extract will definitely find great use in cotton industry especially in green, brown and yellow colour range dyeings [Vankar Padma S, Shanker Rakhi and Srivastava Jyoti, Ultrasonic dyeing of cotton fabric with aqueous extract of Eclipta alba, Dyes Pigments, 2007, 72 (1), 33-37].

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The natural food colorants, carotenoids, are of great importance to human health. The scientists at Department of Agricultural, Food and Nutritional Science, University of Alberta, Canada enhanced the efficiency of SC-CO₂ extraction of carotenoids from carrots, by using canola oil as a continuous co-solvent. The carotenoid content of the starting material was determined by traditional solvent extraction and carrot samples with different particle size and moisture content were extracted with SC-CO₂ at different temperature, pressure, canola oil concentration and CO₂ flow rate for 4 hours. Carotenoids were identified and quantified by HPLC analysis. The α-carotene, β-carotene and lutein were the main carotenoids in the extracts. When canola oil was added as a co-solvent, the α- and β-carotene yields were improved more than twice and lutein yield was more than four times higher compared to those obtained with SC-CO₂ extraction alone. Both increasing temperature and pressure had significant positive effects on the carotene yields except for that of lutein. Larger particle size had a negative effect on carotenoid yields. The α- and β-carotene yields decreased with moisture while the lutein yield increased. Higher carotenoid yields were achieved after 4 hours of extraction at higher flow rate, while more carotenoids were solubilized in SC-CO₂ at lower flow rate. The highest carotenoid yields were obtained at 70°C, 55.1MPa, 5% canola oil concentration (w/w of CO₂), 0.25-0.5 mm particle size, 0.8% moisture content of feed material, and 2L/minutes CO₂ flow rate. Employing canola oil as a continuous co-solvent in SC-CO₂ extraction is a novel and efficient technique for the recovery of carotenoids from natural materials [Sun Mei and Temelli Feral, Supercritical carbon dioxide extraction of carotenoids from carrot using canola oil as a continuous co-solvent, J Supercrit Fluids, 2006, 37(3), 397-408].

The year-round shortage of animal feed demands search of new and nutritional sources. Fodder tree/shrub legumes leaves have the potential for alleviating some of the feed shortages and nutritional deficiencies. The scientists at Department of Animal Nutrition, Punjab Agricultural University, Ludhiana, India assessed the nutritive value of promising tree leaves as livestock feed. The preliminary screening of tree leaves (nine species) by in vitro gas production technique revealed that leaves of Azadirachta indica A. Juss., Melia azedarach Linn., Morus alba Linn. and Leucaena leucocephala (Lam.) de Wit could serve as promising, alternate feed resource for ruminants. Therefore, in vivo evaluation of these tree leaves (except A. indica) along with that of Cedrela toona Roxb. syn. Toona ciliata M. Roem. was assessed. Fresh tree leaves of each species, supplemented with mineral mixture and common salt, was offered ad lib as complete feed to three bucks (Beetle×Anglo Nubian×French Alpine; 6 years old of 56.7±1.12kg BW). The data were analyzed by using completely randomized design. Bucks relished all the tree leaves (except C. toona) as indicated by higher (P<0.05) voluntary DM intake and digestibility of nutrients. All the animals were in positive N-balance except those fed C. toona. The N-retention was maximum in animals fed M. alba followed by that in L. leucocephala and M. azedarach. However, the digestible crude protein (DCP)content of M. alba, M. azedarach and L. leucocephala was statistically comparable, while metabolizable energy availability was higher (P<0.05) from leaves of M. azedarach followed by that of M. alba, clearly indicated that leaves of M. azedarach, M. alba or L. leucocephala, supplemented with mineral mixture and common salt, could serve as an excellent complete feed for small ruminants [Bakshi, MPS and Wadhwa M, Tree leaves as complete feed for goat bucks, Small Rumin Res, 2007, 69(1-3), 74-78].