Journal of Food, Nutrition and Agriculture, 2018: 1(1) 40–46
http://dx.doi.org/10.21839/jfna.2018.v1i1.220
ISSN 2616-6550/

Research Article

Natural plant colorants widely used in Vietnam traditional food culture

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(Received: 03-07-2018; Revised 06-11-2018; Accepted 11-11-2018; Published Online 17-12-2018)
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Abstract

The artificial colorants have gradually been being replaced by natural pigments which are becoming increasingly important in Vietnam and other parts of the world due to the potential noxiousness of man-made food dyes to human health. This research covers colorant plants and sources used commonly in the food culture of ethnic communities in Vietnam with current trend toward natural pigments and coloring foods. As a result, we reported 49 species which can be used as natural food pigments and of these, 7 colorant plants used mostly in Vietnam traditional food culture were detailed.

Keywords: Natural pigments, food coloring, colorant plant, Vietnam

Introduction

In recent years, consumers are averting foods containing artificial colorants by reason of associations with possible harmful effects to human health. As a result, food industries have been substituting them by natural pigments and there is a risen world-wide trend towards usage of natural colors in food, pharmaceutical and personal care industries. Moreover, the food industry and nutrition scientists have dedicated numerous studies to discovering natural alternatives for the evolution of natural food colorants. The results confirmed that using natural food colorants brings many benefits. Natural colorants for food made from renewable sources do not cause health hazards. A number of synthetic dyes such as tartrazine and carmoisine are commonly added to foods, but their use has been questioned because of their suspected toxic properties such as damaging liver function and causing oxidative stress. Hence, interest has increased considerably in searching naturally occurring pigments.

Many natural dyes are used as both food coloring and substances that protect health and well being by precluding or even treating diseases. Moreover, the use of natural pigments offers no toxic properties (Kumar and Sinha, 2004). However, endorsement of such new pigment sources as "novel" food colorants mostly demands stringent food safety assessments, even if their long-term use in the respective country of origin has been previously described to be harmless or even to be associated with health-protective properties. Because of the suspected toxic properties of artificial dyes, all countries have promulgated rigorous regulations about the permitted colors to be used as food additives (Kapoor, 2006). This review aims to cover and display knowledge on colorant plants and sources used commonly in the food culture of ethnic communities in Vietnam

Materials and Methodology

The study was conducted to collect real-life interviews and literature references and field survey in the ethnic tribes and communities in almost provinces of northern Vietnam. Field investigations and sample collecting were performed in random chosen regions from 2013 to 2017. We focus on high-density ethnic minorities areas: Tay-Nung people in the Cao Bang and Lao Cai Province; Tai people in the Son La, Lang Son and Tuyen Quang Province; H' Mong people in the Yen Bai, Lai Chau and Dien Bien Province; Muong people in Hoa Binh; Trai-San Diu people in Thai Nguyen; San Chay people in Bac Kan. A data-base was collected from participant observation and semi-structured interviews with questionnaires regarding the local knowledge on utilization of colorant plants in traditional food culture. The data were processed by basic mathematic method in micro-soft excel.

Results and Discussions

Colorant plants could be used in traditional food culture in Vietnam

Our survey results show that there are forty nine species belonging to 30 families giving pigments for food coloring described in Table 1. Indigenous tribes use botanies for dyeing in traditional food and national festivals. Among forty nine, twelve species are consumed for red color, thirteen species for yellow, eleven species for black and other colors. *Peristrophe bivalvis* has diverse varieties for different colors.

Colorant plants used mostly in Vietnam traditional food culture

In the present study, in comparison with previous study in Vietnam (Dam *et al*., 2016), we found and added nine

Table 1. Checklist of natural colorant plants for food in Vietnam

Sl. No	Family name	Latin name	Vietnamese name	Part containing	Colors	Food
1	Acanthaceae	*Dicliptera chinensis* (L.) Juss	Diễn	Leaves	Red	Rice
		Peristrophe bivalvis (L.) Merr. (several cultivars)	Cẩm	Leaves	Red, Purple, yellow	Rice
		Strobilanthes cusia (Nees) Kuntze	Chàm mèo	Leaves	Black	Rice
2	Altingiaceae	*Liquidambar formosana* Hance	Sau sau	Leaves	Black	Rice
3	Amaranthaceae	*Amaranthus caudatus*	Dền tía	Leaves	Red	Drink
		Iresineherbstii Hook. F. ex Lindl.	Nhung hoa	Leaves	Red	Rice
4	Anacardiaceae	*Rhus chinensis* Mill.	Muối	Stem (bark)	Black	Rice
5	Asteraceae	*Artemisia indica* Willd	Ngải cứu	leaves	green	Cake
		Gnaphalium affine D. Don	Rau khúc	Whole plant	Green	Cake
6	Basellaceae	*Basella rubra L.*	Mồng tơi	Fruit	Purple	Rice
7	Bignoniaceae	*Oroxylum indicum* (L.) Kurz	Núc nác	Stem-ash	Black	Cake
8	Bixaceae	*Bixa orellana* L.	Điều nhuộm	Seed aril	Orange, dark-yellow	Rice
9	Buddlejaceae	*Buddleja macrostachya* Wall. Ex Benth.	Búp lệ chùm to	Flower	Yellow	Rice
		Buddleja officinalis Maxim.	Mật mông hoa	Flower	Yellow	Rice
		Buddleja paniculata Wall.	Búp lệ chùm tụ tán	Flower	Yellow	Rice
10	Burseraceae	*Canarium tramdenum* Dai & Yakovl	Trám đen	Fruit	Black	Rice
11	Caesalpiniaceae	*Caesalpinia sappan* L.	Tô mộc	Wood	Red	Rice
		Saraca dives Pierre	Vàng anh	flower	yellow	Rice
12	Cucurbitaceae	*Momordica cochinchinensis* (Lour.) Spreng	Gấc	Seed aril	Red	Rice
		Luffa cylindria (L.) M.J.Roem	Mướp	Leaves	green	Rice
13	Dracaenaceae	*Dracaena cochinchinensis* (Lour.) S.C.Chen	Bồng bồng	Stem	Red	Drink
14	Elaeagnaceae	*Elaeagnus latifolia* L.	Nhót	Leaves	Black	Rice
15	Fabaceae	*Clitoria ternatea* L.	Đậu biếc	Flower	Blue	Rice
		Dalbergia volubilis Roxb.	Trắc leo	Ash	Black	Rice, cake
		Milletia sp	Cát sâm	Stem	Red	Drink
		Vigna cylindrical (L.) Skeels	Đậu đen	Seed	Black	Rice
		Spatholobus suberectus Dunn	Kê huyết đằng	Stem, leaves	Red	Drink, rice
16	Iridaceae	*Eleutherin bulbosa* (Mill.) Urban	Sâm đại hành	Corn	Red	Drink
17	Magoliaceae	*Micheliame diocris* Dandy	Giổi xanh	Leaves	Green	Rice
18	Malvaceae	*Hibiscus sabdariffa* L.	Bụp giấm	Fruit	Red	Drink
19	Marantaceae	*Phrynium imbricatum* Gagnep	Lá dong	Leaves	Green	Rice cake
20	Menispermaceae	*Fibraureatin ctoria* Lour.	Hoàng đằng	Stem	Yellow	Wine
21	Moraceae	*Morus alba* L.	Dâu tằm	Fruit	purple	Drink
22	Myrtaceae	*Rhodomyrtus tomentosa* (Ait.) Hassk	Sim	Fruit	Purple	Drink
23	Pandanaceae	*Pandanus amarylliforlius*	Dứa thơm	Leaves	Green	Rice, cake
24	Poaceae	*Oryza sativa* L. *var. glutinosa Blanco*	Lúa nếp	Wooden ask seed	Black, mordant	Rice, cake
		Thysanolaena maxima (Roxb). Kuntze	Chít	Leaves	yellow	Rice, cake
25	Polygonaceae	*Reynoutria japonica* Hout.	Cốt khí	Tuber	Yellow	Sticky rice
26	Verbenaceae	*Gmelina arborea* Roxb. Ex Sm.	Lõi thọ	Flower	Yellow	Rice
27	Rubiaceae	*Luculia gratissima* (Wall.) Sweet	Gạc nai	Wood	Yellow	Drink
		Gardenia augusta (L.) Merr.	Dành dành	Fruit, flower	Yellow	Rice
		Paederia Lanuginosa Wall.	Mơ tam thể	Leaves	Black	Rice, cake
28	Smilacaceae	*Smilax glabra*	Khúc khắc	Stem	Red	Drink
29	Urticaceae	*Boehmeria nivea* (L.) Gaudich	Lá gai	Leaves	Black	Cake
30	Zingiberaceae	*Alpinia gagnepainii* (Gagnep.) K. Schum	Riềng	Leaves	Green	Rice
		Alpinia officinarum Hance	Riềng	Leaves	Green	Rice
		Curcuma longa L.	Nghệ vàng	Rhizomes	Yellow	Rice
		Curcuma zedoaria (Christm) Rosc.	Nghệ đen	Rhizome	Yellow	Rice
		Zingiber officinale Roscoe	Gừng	Leaves	Green	Rice

plants: *Strobilanthes cusia* (Family: Acanthaceae) *Iresineherbstii Hook.* F. ex Lindl. (Family: Amaranthaceae), *Saraca dives Pierre* (Family: Caesalpiniaceae), *Luffa cylindria* (L.) M.J.Roem (Family: Cucurbitaceae), *Elaeagnus latifolia* L. (Family: Elaeagnaceae) *Spatholobus suberectus* (Family: Fabaceae) *Gardenia augusta* (L.) Merr.

(Family: Rubiaceae), *Smilax glabra* (Family: Smilacaceae) *Boehmeria nivea* (L.) Gaudich (Family: Urticaceae).

Also according to survey results, we recorded that among possible dye plants, there are seven colorant plants (*Peristrophe bivalvis* L., *Liquidambar formosana* Hance, *Basella rubra* L., *Gardenia jasminoides*, *Momordica cochinchinensis* Spreng, *Turmeric* (*Curcuma longa*), *Pandanus amarylliforlius*), which are consumed commonly in Northern Vietnam (Fig. 1).

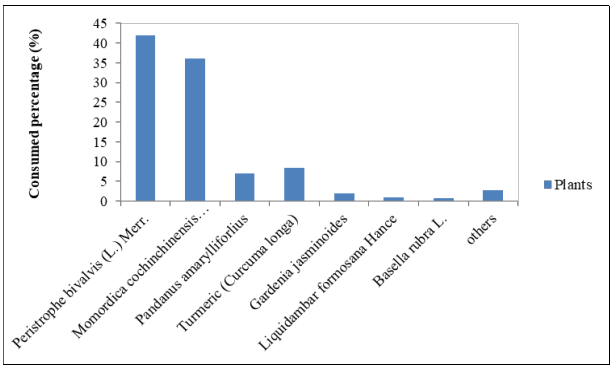

Fig. 1. Percentage of colorant plants consumed in food culture

Peristrophe bivalvis (L.) Merr.

Peristrophe bivalvis (L.) Merr. is known and used widely in food processing as ingredient to look more attractively. Each ethnic tribe and region has a kind of specific traditional food processed with *P. bivalvis,* which make characteristic culture values. Based on the various colors and morphological characteristics of extracts, *P. bivalvis* possesses four colorant types: purples, purple-megenta, yellow, and red (Chi, 1999). *P. bivalvis* has many advantage features applied in biology and pharmacy for blood problems as assisted therapy of high blood pressure, high levels of lipids; inhibiting development of fungi and bacteria (Yang *et al*., 2002; Cheng *et al*., 2004; Verma *et al*., 2008; Wiart *et al*., 2004). Other works also showed prominent bacterial inhibitory capacity of ethanolic extracts (Tanavade *et al*., 2012a, b). Peristrophine is important constituent isolated from the colour water-extract (CWE) of its leaves. Trinh *et al.* (2014) also investigated the acute oral toxicity of the CWE in mice and recorded LD_{50} of the CWE is 9100 ± 290 mg/kg of body weight. In addition, *in vitro* cytotoxic test revealed peristrophine to have HepG2 carcinoma cells growth inhibitory capacity at IC_{50} of 3.90 µg/mL. The antioxidant effect of color extract from this plant also was determined by Nguyen *et al.* (2016).

Momordica cochinchinensis Spreng

Gac (*Momordica cochinchinensis* Spreng.), a tropical fruit, classified in the Cucurbitaceae is used both as a food and a traditional medicine in many nations as China, Viettnam and Thailand (Hoang, 2007) and East and Southeast Asia countries (Iwamoto *et al*., 1985). The fruit is with a thick yellow mesocarp and red soft and sticky aril (Tran *et al*., 2008). The red aril surrounding the seeds of mature fruit is used to make a dish named as "Xoi Gac" in Vietnamese, a type of famously glutinous rice eaten at traditional holiday and anniversary days. In addition, the premature green fruit is consumed as a vegetable in Thailand (Kubola and Siriamornpun, 2011) and India (Joseph and Bharathi, 2008). The red aril is rich in lycopene and *β*-carotene content and they are seen as a great natural red colorant. The highest content of lycopene in fresh aril in absolutely ripe fruit was reported as 3.728 mg/g while *β*-carotene was 0.379 mg/g (Nhung *et al*., 2010). Lycopene level is at higher five times compared to the tomatoes (Rao and Agarwal, 1999; Lenucci *et al*., 2009) and the *β*-carotene level is higher eight times compared to the carrots (Cefola *et al*., 2012). Two these constituents are reported to have high antioxidant effects (Aoki *et al*., 2002; Kubola *et al*., 2011). Recently, there are several reports of using potential of the Gac aril as a natural material to made food dye. The red aril powder could be used to enhance a yellow red color in many recipes such as glutinous rice, yogurt, cheese sauce and fettuccine pasta (Hoang, 2007). The content and retention of β-carotene and lycopene in Gac aril was changed by various temperatures. They significantly reduced in temperature condition at too high. The temperature at 60°C is the best to make natural food colorant (Tanongkankit *et al*., 2014).

Turmeric (*Curcuma longa*)

Turmeric (*Curcuma longa*) rhizome, an important tropical spice, belongs to ginger family Zingiberaceae (Aggarwal *et al*., 2005). The yellow savoury powder produced from its zhizomes have long been utilized in traditional medicince (Joshi *et al*., 2009). The attention has increased considerably over the years because of its benefits in the food colorant processing manufacture (Aggarwal *et al*., 2003). Although it is used popularly as a yellow flavour spicy in household, using to process sweet dishes is restricted because of its specific taste. Eating turmeric daily diet can help to protect and enhance human health (Nishiyama *et al*., 2005). Curcumin is the main coloring principal component extracted from its zhizomes and used as replacements for artificial dyes in the food processing field (Govindarajan, 1980). Yellow of turmeric is formed by three major colorant including curcumin, bis demethoxy curcumin and demethoxy curcumin (Khurana and Ho, 1988). Antioxidant capacity of them was reported by Toda *et al*. (1985). Yellow curcumin is seen as a food preservative agent and has great worth in pharmaceutical manufacture (Sampathu *et al*., 2000; Liang *et al*., 2007). Its anti-microbial evidences were also developed by Egan *et al*. (2004).

Pandanus amarylliforlius

Pandanus amaryllifolius, a tropical plant, is widely cropped and used as a natural green dye in Vietnam and other nations because its leaves contain high chlorophylls. Its leaves can be used to repel insect such as American cockroaches (*Periplaneta americana* L.) and also to produce dye in the food industry. Pandan consists of the following aromatic compounds, namely, 2-acetyl-1-pyrroline which was found in Basmati and Jasmine rice (Jiang, 1990; Laksanalamai and Ilangantileke, 1993). This plant can be a potential source of natural green pigment (Al-Alwani *et al*., 2017). Antioxidant effects were confirmed by the presence of quercetin (Miean and Mohamed, 2001), and other chemical components such as (Ferruzzi *et al*., 2002; Lee *et al*., 2004; Nor *et al*., 2008). It can be thought that *Pandanus amaryllifolius* is a worth source to make green pigments applied in food processing because of its values (Wissgott and Bortlik, 1996).

Gardenia jasminoides

The fruit of gardenia (*Gardenia jasminoides* Ellis.) was commonly used not only as a natural yellow dye but also one of the popular folk medicines since the detection of its

biological property a few decades ago. Xiao *et al*. (2017) reported over 60 chemical compounds isolated from this plant. It has been used for the treatment of inflammation, fever, jaundice, headache, edema, hepatic disorders and hypertension (Tseng *et al*., 1995), and the extracts of gardenia fruit are in yellow or red (Toshiro and Shigeru, 2000), and have been consumed as food colorants in noodle and confectionery products in oriental countries (Yamada *et al*., 1996). In Japan, some 320 tons of gardenia yellow are consumed (Thantsin, 2011), and requirement has been increasing. Both water and ethanol extracts from its fruits had been found to exert antioxidant capacity. The water extract had a higher antioxidant compared to the ethanol extract (Pham *et al*., 2000). *G. jasminoides* - ethanolic extracts showed a protective effect against potential gastric disease due to the presence of ursolic acid and genipin which induce the death of AGS and SUN638 gastric cancer cells (Lee *et al*., 2009).

Antihyperlipidemia: the water extracts of *G. jasminoides* contain crocin displaying antihyperlipidemic effect. Crocin and crocetin significantly decreased the triglyceride and total cholesterol, but there is a significant increase in the high density lipoprotein-cholesterol levels in tested mice (Lee *et al*., 2005).

Retinal demaging inhibition: Crocetin (100 mg/kg, p.o.) reduced retinal damage due to their antioxidant potential and by down-regulating caspase-3 and -9 activities after retinal damage. Moreover, crocetin showed improvement capacity of the quality of sleep in healthy adult man (Yamauchi *et al*., 2011); Ishizuka *et al*., 2013) and crocetin at dose of 50 mg/kg for 2 hours after resuscitation significantly relieved renal dysfunction induced by hemorrhage shock and resuscitation (Wang *et al*., 2012).

Liquidambar formosana Hance

Leaves of *Liquidambar formosana* Hance (LH) has been consumed as a rice dye for anniversary food by a small indigenous tribe in Guangxi province China (Wang *et al*., 2009). The LH leaves can be boiled and crunched for use in the soaking of sticky rice to make black and shiny rice with delicious taste (Chen, 1998). Zhang *et al.* (2017) reported 22 chemical constituents including phenolic acids (gallic acid, digallic acid, 3,5-dihydroxy-methoxybenzoic acid, ethyl gallate, gallic acid derivative, ethyl gallate-O-gallic acid, ethyl gallate-O-gallic acid isomer); flavanols (Catechin and Catechin derivative), flavonols, tannins and lignin isolated from its leaf. Ouyang *et al.* (2016) had reported 68 chemical constituents in the LH. The different solvent extracts from leaves showed outstanding antioxidant being higher positive control (Butylated hydroxytoluene) (Wang *et al*., 2010). As a kind of natural pigment resources, the LH has great potential in foods and cosmetics industry. Its leaves, a natural antioxidant source, are used as both a pigment and an important source in medicine and health care. All parts of this plant could be used in traditional medicine. The leaves have a clear aroma when rubbed, weinxin and a slightly bitter flavor (Huang *et al*., 2000) and are used as heat antidotes, to arrest diarrhea, and to treat dysentery, treat pain, heatstroke, postpartum wind, and pediatric tetanus neonatorium. Other studies also reported that its leaves possess many pharmacological functions as the treatment of diabetes and blood pressure (Zhong *et al*., 2010). Antibacterial effects were evaluated by Zhong *et al*. (2007) and Zheng *et al*. (2005). Leaves extract showed the growth inhibitory capacity of human leukemia K562 cells (Xei *et al*., 2015) as well as enhance non-specific immune and cellular immune functions in normal mice (Zhong *et al*., 2012). Extracts of the LH displayed significantly cytotoxic on human colon adenocinoma cells HT-29 (Zhang *et al*., 2015). Some compounds from this plant also showed significant cytotoxicity against tumor cells (Dat *et al*., 2004; Yang *et al*., 2011). The extracts of LH leaves are commonly used as antibacterial sources in traditional folk medicine in China. L. formosana leaves showed strong effects against *Staphylococcus aureus, Staphylococcus, Shigella flexneri* (Zhong *et al*., 2007). Anti-inflammatory activity was also reported (Hua *et al*., 2014; Yang *et al.*, 2013).

Basella rubra L.

Basella rubra L. belonging to Basellaceae has the potential benefits of pigment rich fruit extracts in food culture (Kumar *et al*., 2015a). Moreover, the pink colored tender twines and leaves of *B. rubra* are known as a leafy vegetable (Kumar *et al*., 2015b). Its ripened fruits possess plenteous betalains that can be used as food grade natural colorants. Fruit extracts contain phenolic acids (coumaric acid, generic acid, ferulic aicd and sinapic acid); flavonoids (myricetin, quercetin, luteolin, apigenin and kaemferol) (Kumar *et al*., 2015c). Kumar and Giridhar, 2016 have reported 348.2 mg/100 g of betalains with 296.6 betacyanins and 51.6 mg/100 g of betaxanthins from the fruit extracts (Kumar and Giridhar, 2016). Betalains are the water soluble natural red and yellow colored indole derived pigments found in the vacuoles of plant cells and have great potential as a natural dye in food processing industry and in pharmacology as antioxidant, anti-inflammatory, and detoxifying agents (Kanner *et al*., 2001).

Conclusion

In traditional food culture of Vietnam, though 49 species can be consumed as natural pigments, 7 species were used mostly. Bioactive and pharmacological studies on their extracts and main bioactive components were reported. Based on real-life interviews and literature references and field survey, these data are firm evidence for further clinical application and also recommend producing in food processing and pharmaceutical industry.

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