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HARMFUL HEALTH HAZARDS OF FOOD COLOURS USED IN INDIA: A REVIEW

R. P. Goyal[1]*, Meera Agarwal[2], Alka Chauhan[2] and Gunjan Sharma[1]

[1]The Cell and Environment Unit, Centre for Advanced Studies, Department of Zoology, University of Rajsthan, Jaipur-302 055Rajasthan, INDIA
[2]Reproductive Physiology and Biochemistry Unit,Centre for Advanced Studies, Department of Zoology,University of Rajsthan, Jaipur-302 055Rajasthan, INDIA

Summary

There are eight rights that have been granted to consumers by the United Nations and the Consumer International. These eight include the Rights to Safety, i.e. to be protected against services, production processes which are hazardous to health and life; the Right to Choose, anti-monopoly laws, the Right to be Heard, to advocate; the Right to Redress, fair settlement of just claims, the Right to Consumer Education, the Right to Healthy Environment and so on. To be able to exercise these rights, the consumer is expected also to act responsibly and fairly in the market place.

What is more important among these rights is that very first is about the safety of health and life of the consumer. But in reality the consumer is most vulnerable and unsafe today in India, specially with regard to the use and misuse of food colours. Most of the coloured food and food products sold in the markets today, are violating the Pure Food Rules in force, specially in respect of food colours. Indians are known to have sweet tooth, spending billions of rupees on sweets in routine and on different social and special occasions. Cheap industrial dyes containing cancer producing chemicals are used by vendors, large and small manufacturers unregistered sweet and candy manufacturers all over the country.

Key Words: Food Colors, Toxicology, health hazards

Introduction

The current wave of appalling shortage and scarcity of food and agricultural produce throughout the world has resulted in the spiralling prices of eatables. Implicit in the situation is another serious problem of adulteration of food which has recently made its dreadful appearance on a scale rarely witnessed in the past. The contamination of food products with cheap and easily available adulterants of known and unknown toxicity may pose serious health hazard to the public. Among various contaminants of food, the use of food colours, in particular, have attained alarming dimensions in the recent years (FAO/WHO, 1978)[1].

Dr. R. P. Goyal*, [1]The Cell and Environment Unit , Centre for Advanced Studies, Department of Zoology, University of Rajasthan, Jaipur, India-302 055 * E-mail ID: drrpgoyal@hotmail.com, Contact no: +91-9314528312

Colour is the first notable characteristic of a food and has an instantaneous visual impact on the minds of consumers. Addition of colour gives food an attractive and appetizing appearance, and also enhances acceptability (Newsome, 1986 and Hallagan, 1995) [2,3]. An attractive colour is associated with quality and freshness and a non attractive colour makes a product look stale and is likely to be rejected.

This article explains the hazards of food colours, their implications and risks to the safety of health and life of people in India.

Reasons of Using Colours in Food

Many foods today do not display their natural colour (Ollikainen, 1982)[4]. Food producers commonly select, modify and standardize the colours that we see and come to associate with specific foods. Consumers are conditioned to expect food of certain colours and reject any deviation from their expectations. Additionally, numerous sociological, psychological, technical and economic factors have also influenced the extensive use of food colours (Downham and Collins, 2000)[5]. However some of the primary reasons include:

(1) To simulate a natural colour as perceived by the consumer, such as adding red colouring to glace cherries which would otherwise be beige, but sometimes it is for effect, like the green ketchup that Heinz launched in 2000.

(2) To offset colour loss due to natural factors like light, air, extremes of temperature, moisture etc.

(3) To replace natural colour lost during processing, to reduce batch-to-batch variation and to produce products with consumer appeal where no natural colour exists (Florian *et al*., 2002)[6].

(4) To conceal quality defects and to ensure consistent colour of products e.g. confectioneries and dessert products.

(5) To fulfill the demand for stable and vivid colours in ready to eat foods.

Most manufacturers use different food colours in their bakery products such as cakes, biscuits and pastries. Similarly they are often used in the manufacture of soft drinks, various kinds of toffees, ice creams, jams and jellies etc, both by street vendors and large manufacturers. Even housewives use food colours to colour rice and other dishes, mainly to give them a more appetizing look.

Background

No doubt that the colour additives have long been used as a means of enhancing the aesthetic value of foods, beverages and cosmetics, and for identifying drugs and other products yet their safer use is most important to health and life. Archaeological evidence dates the use of colour additives in cosmetics to 5000 B.C. The evidence of the use of colour additives in drugs is documented in ancient Egyptian writings and history. At least from 1500 B.C., natural substances such as turmeric, paprika and saffron, and inorganic mineral pigments were in use.

In the middle of the nineteenth century, synthetic organic dyes were developed creating, a more economical and extensive array of colourants. Since then the quality and variety of these colours have improved considerably due to a lot of research and development being carried out on their different aspects. According to an estimate about 1000 tonnes of certified food colours are used in the USA alone.

Basic Chemistry of the Spice Box of Food Colours

Essentially there are three types of coloured dyes. The industrial dyes are used for colouring plastics and dyeing fabrics, the pigments are used by the paint industry which contain injurious chemicals like cobalt, arsenic, mercury and their compounds and the last are food colours. Out of these three the food colours, developed after prolonged experiments for the safety of humans, are generally the most expensive.

There are three main classes of colour in foods: natural colours, browning colours, which are produced during cooking and processing, and additives. The principal natural colours, most of which, in refined form, are used as additives, are the green pigmentchlorophyll, the carotenoids, which give yellow to red colours, and the flavonoids, with their principal subclass the anthocyanins, which give flowers and fruits their red to blue colours.

There has been much interest in carotenoids in recent years, especially betacarotene. Besides being a natural orange pigment (carrots, mango, papaya, winter squash, etc.) it is converted in the body to vitamin A and has antioxidant powers. It is believed to have a beneficial effect in reducing the risk of some cancers and perhaps heart disease. Increasingly, food additive colours are based on anthocyanins derived from sources such as red grapes or beet but the first additive colours were the synthetic dyes.

When synthetic dyes were discovered (mauve was the first, discovered in 1856 by the English chemist William Perkin) they were initially used in textiles, but by 1900 eighty chemical dyes were in use in food in the USA. Chemical dyes have stronger colours than natural colouring agents such as cochineal. Many of these dyes were originally derived from coal-tar, and were commonly called 'coal-tar dyes'. The term is still sometimes used although the dyes are no longer made from this source. Chemically, the dyes are azo dyes, that is they contain the azo group, which confers bright colours which vary in hue depending on the rest of the molecule. Colours chemicals are by definition active chemicals, and hence require greater care than bland additives such as emulsifiers. In 1937 the dye butter yellow (dimethylazobenzene) was found to cause cancer in rats. So the other azo dyes also became suspects and one by one they have been weeded out of the list of acceptable food colour additives. Today a limited range of azo dyes is used in food. All have been extensively tested. So long as they are fully tested, there is no excuse for the puritanical attitude that adding colours to food is wrong. Why did we add colour to the television, the newspapers and to our computers? Colour is one of the greatest life enhancers we have. The challenge for the chemist is to devise colours that are safe to use in foods. It isn't enough to say" use natural colours. Natural colours are also chemical pigments. Many foods using natural

colours, are unlikely to reach supermarket shelves with their natural colour at its peak. The most notorious examples are canned foods, such as peas and strawberries, which would be khaki and dull brown, respectively, without the addition of food colour.

Chocolates

Candies

Shakes

Muffins

Cakes

Biscuits

Pastries

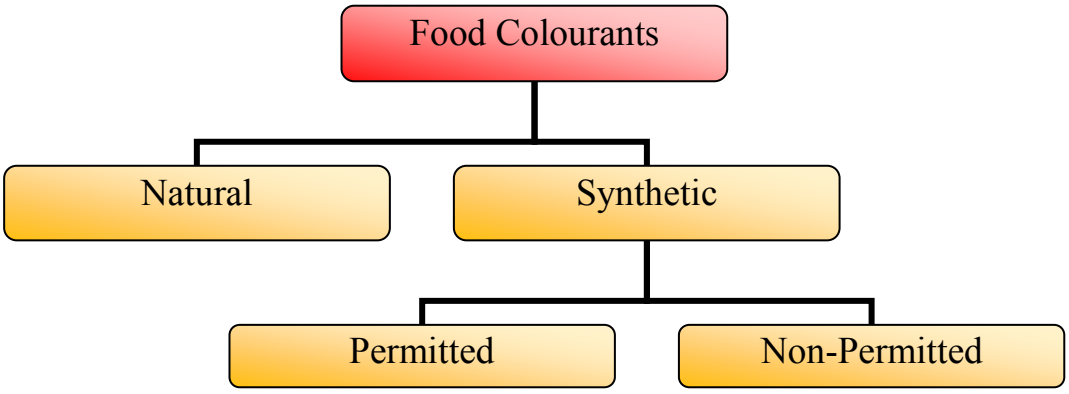
Shakes

Common items with food colours available in Indian Market

The main trend in colour in food is towards the use of anthocyanin colours. No doubt 'anthocyanin' will become another additives bogey word for some people, but it should be remembered that anthocyanins are the principle of pigment employed by nature in flowers and fruits. At present they are mainly consumed in foods which naturally contain them. But they will increasingly be consumed as additives which have been extracted from one plant source and used to colour totally different foods.

Some sources of anthocyanins, besides red grapes, are elderberries, red cabbage, blood orange, the less familiar black chokeberry, and the sweet potato. Anthocyanins are highly dependent on acidity and lose their colour in conditions of low acidity. Therefore, the scientific developments in the field of anthocyanins to produce those which are more stable across a range of acidities is likely. There has been much recent activity in the field of red anthocyanin pigments with red potatoes, beet and amaranth (a relative of the beet family) to the fore.

General Classification of Food Colours



(1) Natural Food Colourants

These colourants are of natural origin and are derived from vegetable sources such as chlorophyll, carotenoids, flavonoids, anthocyanins, carotene, curcumin, carmine, beetroot etc. or from animal sources such as cochineal. Natural colourants are also called “Biocolours” because of their biological origin (Pattanaik *et al.*, 1997)[7]. They have been used to colour foods, drugs and cosmetics for the thousands of years. These colours are permitted in any food, and in any proportion (Paul, 2003)[8].

(2) Synthetic Food Colourants

These colourants do not occur in nature and are produced artificially by chemical synthesis. The higher cost and lack of availability of natural colouring materials and difficulty in incorporating these in the modern western technology of processing food might have resulted in the shift towards the usage of synthetic food dyes. Once the flood gates of synthetic colourants were opened, the markets were inundated with artificial colouring agents because of their ready availability, bright colouration, low cost and high tinctorial strength (Babu and Shenolikar,

1995)[9].

(A) Permitted Food Colourants

In India, implementation of the Prevention of Food Adulteration Act, 1954 (PFAA, 1954)[10] was a bold step to check use of unauthorized harmful/toxic substances in food. The Prevention of Food Adulteration Act (1954) permits only eight synthetic dyes to be used as food colourants. These include Tartrazine, Sunset yellow, Carmoisine, Ponceau 4R, Erythrosine, Brilliant blue, Indigo carmine and Fast green. These colours are permitted to be used within the limit specified for the particular item. For all the dyes, the maximum limit has been fixed at 0.20 gm/kg of food. Moreover, it is mandatory to declare the addition of the artificial colour on the label of the food product (PFA, 2003)[11].

In United States of America, Food and Drug Administration (FDA) is responsible for regulating safe use of the colour additives and FD & C (Federal Food, Drug and Cosmetic Act) numbers are given to the approved dyes. In the European Union, European Commission ensures that the coloured foods are safe to eat. They use E number system to label permitted colour additives across the range of languages in the European Union.

To suffice, only 8 synthetic colourants are allowed in India, 9 in the United States (US) and 11 in the European Union (EU). The majority of the permitted food colourants belongs to the class of azo dyes (De Vries, 1997)[12].

(B) Non-Permitted Food Colourants

Synthetic permitted food colours are available in the market but being more costly; traders take advantage of lackadaisical approach of the law enforcing authorities and substitute it with cheap and easily available non-permitted food dyes (Giri, 1991)[13].

Non-permitted food colours have been toxicologically classified under the category C II and C III by the Joint FAO/ WHO Expert Committee on Food Additives which implies that the available toxicological data is inadequate for safety evaluation but indicates the possibility of harmful effects and for which virtually no information on long term toxicity is available. This has been the main ground for non inclusion of these dyes in the prescribed list of food colours.

According to food regulation in many countries, the following synthetic food colours are not permitted to be used:

(i) Metallic dyes – They contain compounds of any of the metals such as Antimony, Arsenic, Cadmium, Chromium, Copper, Mercury, Lead and Zinc.

(ii) Azo dyes – They are synthetic colours that contain an azo group

(-N=N-) such as Auramine (yellow), Blue VRS (blue), Orange G, Congo red, Sudan II and III (red), Metanil yellow, Orange II (yellow to orange) and Rhodamine B (pink).

It is a matter of serious concerns that in spite of regulatory surveillance the use of non-permitted colours in some loose/non-banded products in both rural and urban markets is continuing. Majority of non-permitted food dyes such as Metanil

yellow, Orange II, Rhodamine B, Malachite green, Auramine, Amaranth and Sudan dyes are known to cause varied toxic manifestations in the experimental animals (Fernandes *et al*., 1991; Mahudawala and Rao, 1999; Rao, 1995; Tsuda *et al*., 2001 and Zahn and Braunbeck, 1995)[14-18].

A brief about some surveillance studies conducted in India

As part of surveillance of food contaminants in India, the Indian Council of Medical Research (ICMR) had tested 249 samples of turmeric collected from rural and urban market of Assam, Maharashtra, Karnataka and Andhra Pradesh in 1993, 47.8% of the sample showed the presence of Arsenic, 55.8% had Cadmium and 95.1% was contaminated with Lead and its compounds (Girimaji, 1999)[19].

Studies conducted at the Industrial Toxicological Research Centre (ITRC, 1993)[20], Lucknow has revealed that 70% of the market samples contained non-permitted food colours and also food samples analyzed by the National Institute of Nutrition, Hyderabad (NIN) showed a wide range of non-permitted colours being used in food items (Bhat *et al*., 1994 and Paul, 2003)[21, 8].

In the central and suburban areas of Kolkata few foods, manufactured by unorganized private sector and small vendors, did contain colours in higher concentration than the permitted range (Biswas *et al*., 1994)[22]. Incidences of the use of non-permitted food colours and colours above permissible limits were higher in case of the unorganized food makers.

Waghray and Bhat (2001)[23] have reported that in the street foods like jalebi, sugar toys, lollipops, sweat meats, savouries, fresh peas, aniseed etc. sold by vendors in both urban and rural areas contained non-permitted colours like Orange II, Rhodamine B, Auramine etc.

Previous findings in our Research laboratory

Toxicological hazards concerned to the effects of food colours are extensively studied clinically in our research laboratory are tabulated herein:

S.No.	Title of Research Study	Details of Publication
1.	Haemotoxic effects of Chocolate Brown, a commonly used blend of permitted food colour on Swiss albino mice, *Mus musculus*. [24]	Asian Journal of Environmental Sciences 2005. 10(2):93-103
2.	Haematological changes induced by a common non-permitted food colour, malachite green in Swiss albino mice. [25]	Indian Journal of Environmental Sciences 2005. 9(2):113-117.
3.	Orange Red, a blend of permitted food colour induced haematological changes in Swiss albino mice, *Mus musculus*. [26]	Bulletin of Pure and Applied Sciences 2005. 24(2):99-103

4.	Toxicological studies of Apple green, a permitted food colour on Swiss albino mice, *Mus musculus*. [27]	Indian Journal of Environmental Sciences 2006. 10(1):21-24
5.	Haematological and serological toxicity of Orange G in Swiss albino mice, *Mus musculus*.[28]	Nature Environmental and Pollution Technology 2006. 5(1):95-99
6.	Tomato red toxicity: Haematological and Serological changes in the blood of Swiss albino mice, *Mus musculus*. [29]	Indian Journal of Environmental Sciences 2006. 10(2):145-148.
7.	Haematological and serological studies on Swiss albino mice fed with lead chromate. [30]	Journal of Ecotoxicology and Environment Monitoring 2007. 17(1):61- 66.
8.	Toxicity of tomato red, a popular food dye blend on male albino mice. [31]	Experiment and Toxicologic Pathology. 2008. 60 (1):51-57
9.	Tartrazine induced haematological and serological changes in female Swiss albino mice, *Mus musculus* [32]	Pharmacologyonline 2009. 3: 774-788.
10.	Evaluation of toxic impact of tartrazine on male Swiss albino Mice. [33]	Pharmacologyonline 2010. 1: 133-140
11.	Effect of Kesari Powder on Haematological and Serological parameters in female swiss albino mice [34]	Pharmacologyonline 2010; 2: 425-444

Beware of Food Colours--Food Hazards

We should not be tempted by colourful foodstuffs stacked on the shelves of roadside eateries, everywhere these days. These colours can cause damage to liver, kidneys and heart, as well as skin, eyes, lungs and bones. If one feels restless, dizzy or irritated and suffers from nausea or diarrhoea, after eating something from the market, we should blame the yummy red jalebis eaten at the wayside shop or the coloured biryani rice or perhaps, the mouthwatering vanilla ice cream which makes some people go crazy.

Conclusions

The following conclusions can be drawn to follow up and regulate the use/misuse of Food Colours in India.

1. Approved food colours are not dangerous to health, so long as their use is limited to approved food items, as well as with in the permitted amounts of the food rules.
2. Overuse of approved and the use of unapproved food colours, is quite prevalent in the consumer market of food and food products.
3. Public awareness about the serious health risks/dangers due to the food colours, being used in the food and food products market, is non-existent It is highly important to raise this awareness level significantly, using print and other electronic media.
4. The situation appears more serious in sweets, candies, pan-supari, chillies, small scale ice-cream vending at school gates etc. Not worthy is the fact that the main food items of concern are children's favourites, meaning that children are exposed more to health risks in this harmful business of food colours.
5. Food laws enforcement agencies at local and provincial levels are not properly qualified, trained and are ill-equipped to deal with the problem of food colours. It demands priority attention of the responsible government departments.
6. There is also a need forthe awareness and some basic training to food inspectors, about the use and misuse of food colours and the consequences thereof like the use of textile dyes in the food items.
7. List of approved food colours given in the Pure Food Rules of 1965 need revision in the light of latest scientific developments from Codex Alimentarius, FAO and WHO. For this purpose an Experts Committee be constituted to delete or add to the list of food colours Pakistan Focal Point for the Codex must be included in this Committee.
8. A "Task Force on Food Colours" should be constituted by the government with members from the consumer groups, NGOs and government departments to monitor the situation with regard to the use of food colours in food products. The Body should also have the mandate to take measures and guide/advice the government on methods and policies to eliminate the health risks to consumers as a result of food colours.

Natural Colours--A Part of the Solution

One solution to the whole synthetic colourants could be natural colours which are considered inherently safe and pure. Before synthetic colours came into existence, chilli, ratanjot, safron, turmeric were used by the people of the Subcontinent to literally addcolour to food recipes. It is time that we revive these traditional natural colourants. We should develop our technology for the manufacture of certain natural food colours at PCSIR, and other R&D organisations, such as beetroot (red), safflower (yellow), kokum (red), grapes (pink), chillies (red) and so on. It is understood that at Central Food Technological Research Institute (CFTRI), Mysore, India the mechanism has been successfully developed to

achieve the yellow colouration of ice cream by incorporating curcumin which is a natural yellow colourant derived from turmeric.

We, as scientists as well as consumers, should also remember that even some of the natural colours are crude extracts of plant pigments and hence these plant food colours should also be subjected to some kind of toxicological testing to ensure their safe use.

References

1. FAO/WHO: Evaluation of certain food additives. WHO technical report series No. 617, 21st report of the Joint Food and Agriculture Organization and World Health Organization (FAO/WHO) Expert Committee on food additives. 1978, Rome.
2. Newsome RL. Food colours. J. Food Technol. 1986; 40: 49-52.
3. Hallagan JB, Allen DC and Berzelleca JF. The safety and regulatory status of food, drug and cosmetics colour additives exempt from certification. Food Chem.Toxicol.1995; 33: 515-528.
4. Ollikainen TH. Pleasantness of colourless and decoloured soft drinks and consumers attitudes to artificial food colours. Appetite.1982; 3: 369-373.
5. Downham A. and Collins P. Colouring our foods in the last and next millennium. Int. J. Food Sci. Technol. 2000; 35: pp 5-22.
6. Florian M, Yamanaka H, Carmeiro PA and Zanoni MVB. Determination of Brilliant blue FCF in the presence and absence of Erythrosine and Quinoline yellow food colours by cathodic stripping voltametery. Food Addit. Contam. 2002; 19: 803-809.
7. Pattanaik P, Roy U and Jain P. Biocolours: New generation additives for food. Ind. Food Indust. 1997; 16: 21-27.
8. Paul R. Beware of additives. Sci. Reporter. 2003; July, pp 59-61.
9. Babu S and Shenoliker IS. Health and nutritional implications of food colours. Ind. J. Med. Res. 1995; 102: pp 245-249.
10. PFAA. Prevention of Food Adulteration Act, Rule. *16th ed.* Indian Eastern Book Company, 1954.
11. PFA. Prevention of Food Adulteration Act of India, 1954 and Rules. Lucknow, India: Indian Eastern Book Company, 2003
12. De Vries J. Food additives. In: Food safety and toxicity. CRC press. 1997; pp 122.
13. Giri A. K. Food dyes of India: Mutagenic and clastogenic potential - A Review. Proc. Ind. Natl. Sci. Acad. 1991; 57: 183-198.
14. Fernandes C, Lalitha VS and Rao KVK. Enhancing effect of Malachite green on the development of hepatic pre-neoplastic lesions induced by N-nitrodiethylamine in rats. Carcinogenesis 1991; 12:839-845.

15. Mahudawala DM and Rao KVK. Sequential enhanced tyrosine phosphorylation during progressive Malachite green induced malignant transformation of Syrian hamster embryo (SHE) cells in culture is associated with no change in the activity levels of tyrosine phosphatases. Ind. J. Exptl. Biol. 1999; 37: 423-428.
16. Rao KVK. Inhibition of DNA synthesis in primary rat hepatocyte cultures by Malachite green: a new liver tumor promoter. Toxicol. Lett. 1995; 81: 107-113.
17. Tsuda S, Murakami M, Matsusaka N, Kano K, Taniguchi K and Sasaki Y F. DNA damage induced by red food dyes orally administered to pregnant and male mice. Toxicol. Science. 2001; 61: 92-99.
18. Zahn T and Braunbeck T. Cytotoxic effects of sub lethal concentration of Malachite green in isolated hepatocytes from rainbow trout (Oncorhynchus mykiss). Toxicol. In vitro. 1995; 9: 729-741.
19. Girimaji P. Laws must to check food contamination. The Tribune, November 14, 1999.
20. ITRC. Annual report. Industrial Toxicology Research Centre, Lucknow, 1993.
21. Bhat RV, Waghray K and Rambabu JP. A report on urban street foods in Hyderabad and Secunderabad. National Institute of Nutrition, Hyderabad, 1994.
22. Biswas G, Sarkar S and Chatterjee TK. Surveillance on artificial colours in food products marketed in Calcutta and adjoining areas. J. Food Sci. Technol. 1994; 31: pp 66-67.
23. Waghray K and Bhat RV. Quality of traditional foods sold in the streets of Hyderabad. J. Res. Angaru. 2001; 29: 51-60.
24. Sharma A, Goyal RP, Chakravarty G and Sharma S. Haemotoxic effects of Chocolate brown, A commonly used blend of permitted food colour on Swiss albino mice. Asian J. Env. Sci. 2005; 19: 93-103.
25. Chakravarty G, Goyal RP, Sharma S and Sharma A. Haematological changes induced by a common non-permitted food colour Malachite Green (MG) in swiss albino mice. Ind J Expt Sci, 2005; 9 (2): 113-117.
26. Sharma S, Goyal RP, Chakravarty G and Sharma A. Orange red, a blend of permitted food colour induced haematological changes in Swiss albino mice, *Mus musculus.* Bull. Pure Appld. Sci. 2005; 24: 99-103.
27. Sharma A, Goyal RP, Chakravarty G and Sharma S. Toxicological studies of Apple Green, A permitted food colour, on Swiss albino mice, *Mus musculus*. Ind. J. Env. Sci. 2006; 10: 21-24.
28. Chakravarty G, Goyal RP, Sharma S and Sharma A. Haematological and serological toxicity of Orange G in Swiss albino mice, *Mus musculus*. Nat Environ Poll Tech 2006; 5 (1): 95-99.
29. Sharma S, Goyal RP, Chakravarty G and Sharma A. Tomato red toxicity: Haematological and serological changes in the blood of Swiss albino mice, *Mus musculus*. Ind. J. Env. Sci. 2006; 10: 145-148.

30. Chakravarty G, Goyal RP, Sharma S and Sharma A. Haematological and serological studies on Swiss albino mice fed with lead chromate. J Ecotoxicol Environ Monitoring 2007; 17 (1): 61-66.

31. Sharma S, Goyal RP, Chakravarty G. and Sharma A. Toxicity of Tomato Red, a popular food dye blend on male albino mice. Expt Toxicol Pathol 2008; 60 (1), 51-57.

32. Sharma G, Gautam D and Goyal RP: Tartrazine induced haematological and serological changes in female Swiss albino mice, *Mus musculus* Pharmacologyonline 2009; 3: 774-788.

33. Gautam D, Sharma G and Goyal RP. Evaluation of toxic impact of tartrazine on male Swiss albino Mice. Pharmacologyonline 2010; 1: 133-140.

34. Sharma G, Sharma S, Dixit A, Gautam D and Goyal RP. Effect of Kesari Powder on Haematological and Serological parameters in female swiss albino mice. Pharmacologyonline 2010; 2: 425-444