METANIL YELLOW, AN ALARMING PROBLEM IN FOOD INDUSTRIES

Abstract

Nowadays, food colour is profusely used in all types of food items that is from raw food to cooked items, beverages, confectionaries and sweets, coloured drinks etc. Among them, some are permitted to be used up to a prescribed upper limit and some are totally non-permitted. For commercial profit, most of the traders use non-permitted, cheap food colours in the food products. One of the most used non-permitted food colours is Metanil Yellow which providesa bright orange or yellow colour in food. A continuous consumption of MTY can cause various diseases in our body like gastrointestinal disorders, cardiovascular diseases, disorders in the reproductive system even in the nervous system.

Key words: Metanil Yellow, Azo Dye, Non-permitted colour, Lipid Peroxidation, Histopathological lesions

Authors

Urbi Roy
M.Sc., 1st semester
Department of Applied Nutrition and Dietetics

Beepsa Basu
Faculty and Ph.D Scholar
Department of Applied Nutrition and Dietetics
Food Science and Nutrition from J.D. Birla Institute
Jadavpur University
Kolkata, West Bengal

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I. INTRODUCTION

Colour is a natural system in the plant kingdom to attract a predator to aid their reproduction and in return, the plant provides them with nutritional and medicinal benefits. Colour is also one of the most potential sensory properties in the arena of food industries asit plays a major role in the taste and perception of food along with flavour and texture. Colourful food and beverages always attract consumers, besides if the food does not look attractive, consumers may reject it.

At the time of food processing, the natural colouration of the food product is slightly or majorly destroyed most of the time. To retain those colours and make the food products more attractive and appetizing, the manufacturers add some additional colours to the food. The colours which are used are categorized into natural and synthetic colours. Natural colours are not harmful to health but synthetic colours, if added more than permissible limits, can exhibit harmful effects.

As natural colours are quite expensive for small or medium manufacturers, they use synthetic colours which are very cheap and easily available. It has been reported that the Indian population consumes 220 mg of synthetic food colours each year due to highly expensive natural products (Singh, 1997).

Among the most commonly used synthetic coloursin India, Metanil Yellow (MTY) is a popular name thatis the **principal non-permitted** food colour used extensively in food products. It is a toxic additive that is majorly used in sweets, pulses, and turmeric as it imparts a bright colour which ranges from yellow to orange. This Metanil yellow (MTY),the highly poisonous and mutagenic azo dye, if used excessively –above its safe permissible limit, can causeliver damage, anaemia, hyperactivity, allergies, infertility, congenital disabilities, and even cancers.(1)

1. **Aims and Objectives:** The use of Metanil Yellow in various food products (Both raw and cooked) is increasing day by even after knowing its harmful effects.
   The main objectives of this review study are –

   - To learnthe physical and chemical properties of Metanil Yellow.
   - To know the use and applications of it.
   - How it shows its harmful effects the human health.
   - Some case study which shows the statistical data on use of MTY.

2. **Methodology :** This review project is carried out through following methods.

   - At firstvarious scholarly articles related to Metanil Yellow are searched from authenticated and verified sources.
   - They are then selected and segregated properly.
   - These articles are gone through and a detailed study has been done on them.
   - Some analysis and comparison of the articles are also done.
   - Then they are summarized as required.
   - After all of these procedures, the final write-up is prepared.

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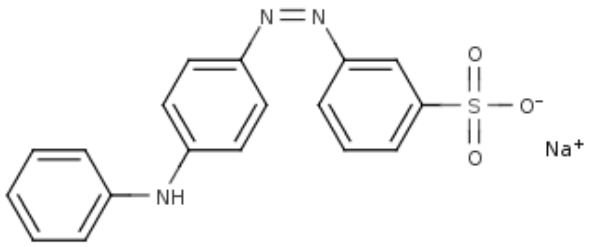
3. **Physical and Chemical propertiesof Metanil Yellow:** Metanil Yellow is an Azo Dye which is an organic sodium salt made from diazotized metanilic acid and diphenylamine and used as a pH indicator with colour range from red to yellow and pH between 1.2 and 3.2. (2) *Physical Property* – MTW is Brownish-yellow in colour and solid or powdered in texture.
   IUPAC Name- 3-[(4-anilinophenyl) diazenyl] benzenesulfonate .

   Molecular Formula- $C_{18}H_{14}N_3NaO_3S$
   Molar Mass- 375.38 g/mol
   Synonyms - Amacid Yellow M;Fenazo Yellow M; Kiton Yellow MS etc.
   Chemical Stucture –



2D Structure of MTW

4. **Uses of Metanil Yellow:** Metanil Yellow has a variety range of uses in India.

- This dye is used in colouring fibres, wool, silk, fur, and nylon; applied in aluminium, detergent, wood, and cosmetics; also in biological stain, printing on paper, ink and more.
- It is used as a pH indicator in laboratories.
- The chief use of Metanil yellow is as the food colour. It is one of the non-permitted dyes used for foods and is present in nearly 25% of all coloured foodstuffs (Khanna et al., 1985).

  Mainly it is used in cereals, pulses, bakery goods, sweets and beverages, candies, ice creams and numerous other commodities.
  In the category of spices, it is used as the leading adulterant for curcumin in turmeric powder.As reported, MTW was found in 16.4% of the sampled food products in India (Nagraja et al., 2011).

5. **Applications of Metanil Yellow:** The major use of MTY isto brighten the yellow or orange colour in the food, spices or beverages. Basically, people do not consume any dull or faded coloured food products, so, to enhance the acceptability of the food, this additives are used broadly. Turmeric powder and sweets(like laddu, jalebi etc) are mostly adulterated with MTY in order to enhance the bright yellow colour. This type of adulteration is economical as per the high demand for bright yellow-coloured turmeric powder or sweets. This toxic chemical azo dye has a wide range of uses in various foodstuffs as it is a very cheap and easily available food colourant and also effective in providing a uniform and intense food colour. It can also be blended easily to give a variety of hues. All of these purposes accelerate the use of MTW widely.

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6. **Health HazardsCaused by Metanil Yellow**: Food gives people nutritional as well as medicinal value. But the toxic additives, and food colorants like Metanil Yellow exert their toxicity when they enter into the body. Daily consumption of this synthetic azo dye has chronic exposure to bloodstream as well as various intrinsic body organs and they may get dangerously affected. Metanil yellow can induce damage in nervous tissue, intestines, gastric tissue, heart, liver, kidneys, i.e. all of the vital organs and organ system.

7. **Effects on the Digestive System:** Consumption of Metanil Yellow occurs directly through the foodstuffs. When it reaches to the digestive system, it causes damage to hepatic cells and intestinal tissues by hepato and gastrotoxicity respectively. A Study conducted in the fish model (*Heteropneustes fossilis*) proved that direct exposure to Metanil Yellow has a huge effect on the disturbance and disarrangement of gastric folds, destructions of Epithelial Cells and loss of micro ridges from the apical plasma membrane and fragmentation. It loosens the structural configuration of absorptive columnar epithelial cells in the intestine. There is a significant elevation in cytochrome **P- 450 (P-450) -dependent aryl hydrocarbon hydroxylase (AHH) activity (99-223%)** in the cells of the liver and intestine. In some cases, it is also noticed that **Cytosolic glutathione-S-transferase (GST) (32-136%)** and **Quinone Reductase (QR) (20-92%)** activities are found to be substantially induced in hepatic and intestinal cells.MTY causes the degeneration as well as destruction of gastric glands and intestinal microvilli which ultimately alters the absorption power of nutrients. Studies in fish models also revealed that excessive exposure to MTY causes extensive degeneration and destruction of pyknosis of nuclei as well as cytoplasm, and damage occurs in the central vein region of hepatic tissues.(5)

8. **Effects on Cardiovascular System:** MTW has its impact on the Cardiovascular System too. An in vitro study occurred on goats' hearts showed that metanil yellow increases **Lipid Peroxidation**, and alters the level of endogenous antioxidant enzymes and catalase, thus accelerating the damage of cardiac tissues.(5)

9. **Effects on the Nervous System :** The nervous system is not excluded from the adverse effects of MTY. It causes damage to brain tissues. Studies show that both the developing as well as adult brain tissues of Wistar rats were affected by the exposure to MTY. In certain areas of the brain like the brain stem, hypothalamus, and stratum, the amine level (neurotransmitters) was adversely affected by the administration of MTW, the toxic dye, orally. Even, though the consumption of MTY had been stopped, the alteration of the nervous system was not reversed. It also causes damage in the granular and Purkinje cell layers of the brain. A regular administration of MTY **decreased the neurotransmitter**,**acetylcholine esterase level** and **delayed decrease in the hippocampus** of Wistar Rats which caused a **delayed learning process**. In the case of long-term administration of MTY, persistent histopathological changes were observed in the brain.(5)

10. **Effects on Excretory and Reproductive System:** The study on the Fish Model revealed that kidneys were severely affected by daily exposure to MTY. There were severe histopathological lesions observed in the kidneys with the cloudy swelling of epithelial cells of renal tubules, necrosis of tubular epithelium and interruption of Bowman's

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capsule, and detrimental changes in the distal convoluted tubule and the collecting tubules.

MTY exerted its toxicity level both in the male and female reproductive systems of the guinea pigs, rats, and mice. In the male reproduction system, the degradation of spermatocytes and seminiferous tubules, testicular tissue damage, and vacuolations in the Sertoli in albino rats were induced by the exposure of MTY. In the females, it causeddisruption of the normal oestrous cycle, inhibited the secretion of FSH and oestradiol from the ovary, impaired the folliculogenesis and induced oxidative stress in hypothalamic–pituitary–gonadal axis.(5) So all these study reports show that regular consumption of MTW can adversely affect the overall Body- systems.

11. **Prevention of using Metanil Yellow:** There are many Strict Rules and Regulations provided by FSSAI (**Food Safety and Standards (Food Products Standards and Food Additives) Regulation, 2011; Food Safety and Standards (Laboratory and Sampling Analysis) Regulation, 2011; Food Safety and Standards (Approval for Non-Specific Food and Food Ingredients) Regulation, 2017**etc.) to prevent the unethical overuses of such toxic food additives like MTY. The regulations state that no colouring matter can be added to food samples or food products unless permitted in these regulations. In spite of having all these curricula, the manufacturers are somehow able to escape from these rules and regulations and profusely use thefood additives beyond the impermissible limit. Though it is very much difficult to prevent this malpractice within a day or two, some measures can be taken, like-

    - Increasing the use of natural colourants instead of using synthetic food colours.
    - Increase the production of Natural Colourants.
    - Decrease the whole cost of natural colourants so that it can compete with the Synthetics.
    - A regular inspection should be held and the proper penalizing should be implemented in case of violating the rules and regulations.Raising mass awareness is the key point to abolish this malpractice. If consumers start to reject the products having MTY, manufacturers won't produce such kind of food products any more.

12. **Doses of use :** Metanil yellow is declared a banned dye in the PFA Act (1954),the Government of India.As per the declaration of FSSAI about food colours on the label (Packaging & Labelling, Regulations, 2011), all Synthetic colours should have a maximum limit of **100 parts per million** of the final food or beverage. According to this regulation, MTY also has the maximum permissible level - 100 mg kg-1 or litre-1 of food products as consumed.(4)

13. **Further findings (research results) :** A Case study was done in West Bengal where 253 food samples (Ladoo, turmeric powder, and besan) were collected from six different districts of West Bengal which are from downtown to country site areas where the distribution of populations are from various financial stratums to find the presence of MTY in those samples. The samples were analysed in the laboratory and the

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Table 1 : Name of the areas from where Samples were collected

Sl. No.	District Name	Areas/Cites/Villages/Metropolitans
1.	Nadia	Kalyani, Payradanga, Kaliganj, Bethuadahari, Plassey, Krishnagar, Chakdaha, Nabadwip, Ranaghat.
2.	Murshidabad	Khagra, Jalangi, Kandi, Lalbagh, Lalgola,Domkol
3.	Kolkata	Shyambazar, Rabindra Sadan, Park Circus, Kalighat, Jadavpur
4.	Midnapur (East)	Panshkura,Tamluk ,Mecheda, Bhagabanpur, Egra
5.	North 24 Parganas	Kanchrapara,Naihati,Barrackpore,Halisahar, Khardaha
6.	Howrah	Amta, Sankrail,Andal,Uluberia,Salkia.

The following results were found after the analysis -

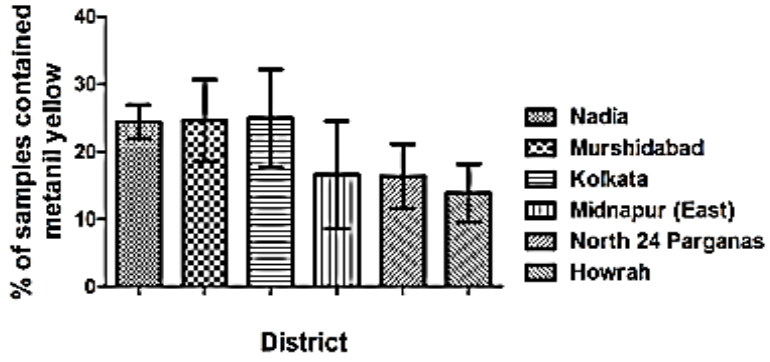

Figure 1: Graphical representation of the percentage of samples contained Metanil Yeallow in selected areas of different districts in West Bengal, India.
(*Image Source: A case study on use of food colour to process food in unorganized sector, West Bengal -Department of Physiology, University of Kalyani*)

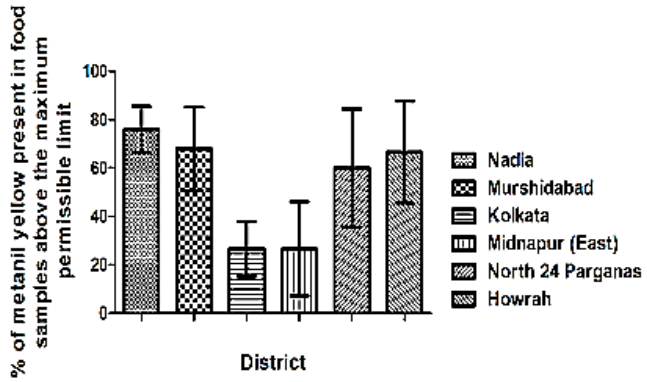

Figure 2: Graphical representation of Percentage of positive samples containing the Metanil Yellow above the maximum permissible limit out of total positive samples obtained from selected areas of different districts in West Bengal, India. (*Image Source: A case study on use of food colour to process food in unorganized sector, West Bengal-Department of Physiology, University of Kalyani*)

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Among the 235 different samples, 58 gave positive results i.e. contained MTY. It was also found that 36.21% of the total positive samples had MTY content below the maximum permissible limit i.e., below the 100 mg kg-1 food samples; 63.79% of the total positive samples had above the maximum permissible limit i.e. above the 100 mg kg-1 food samples as mentioned in the Prevention of Food Adulteration Act(PFA, 2008) of India.(6)

A study was done using Wistar rats to see the regional levels of dopamine, noradrenaline, and serotonin, the activity of acetylcholine esterase (ACHE) on their both adult and developing brains after prolonged consumption of metanil yellow. The amine i.e. neurotransmitter level in the hypothalamus, brain stem and striatum was significantly changed which was irreversible in the case of the treated rats. A rapid reduction of Acetylcholine esterase was seen in the striatum whereas, a delayed and persistent effect of reduced Acetylcholine esterase activity was seen in the hippocampus. The long-term effect of MTY slowed down the learning process as the treated rats took more sessions than untreated rats to learn the operant conditioning behaviour. All these basically proved that MTY can predispose the central nervous system (CNS) of the rat to neurotoxicity. (5)

The Albino Rats were administered MTY orally for 28 days. This resulted in the elevation of total bilirubin and some serum enzymes like alkaline phosphate, glutamate oxaloacetate transaminase, glutamate pyruvate transaminase etc. and a reduction in albumin and total protein levels in blood. The results found at the tissue level were the activities of most of the oxidative stress markers like superoxide dismutase, catalase, and glutathione (in the liver and kidney) reduced to half while malondialdehyde level increased significantly.
Then MTY was co-administered with eugenol/vitamin E/vitamin C and a significant restoration of oxidative stress and renal-hepatic markers in serum and tissues was observed.(7)

Another study revealed that certain phytochemicals which are antioxidant in nature are present in the methanolic extract of Coriandrum sativum that exerts a protective effect on Metanil yellow-induced hepatotoxicity in the in vitro goat liver. This phytochemical shows a protective action against MTY-induced lipid peroxidation in goat liver tissues (in vitro).(3)

II. CONCLUSION

In West Bengal as well as in overall India, MTY is widely used as a food colourant. In spite of knowing the toxic and carcinogenic properties of MTW, it is profusely used in the preparation of varieties food products. Even though people are quite aware of the toxic, adverse effects of this azo dye, they continuously consume the MTY containing food stuffs. MTY possesses numerous harmful effects on human health, the major fatal effect if induction of oxidative stresses in the body cells. So, the consumption of antioxidants can reduce the severity of the poisonous effects of MTY to a certain limit.

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Mainly the coloured food consumption must be restricted and proper precautions must be taken, a regular survey should be conducted by higher authority to reduce the uses of MTY and provide the population a healthy life.

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