Chapter 69

Natural and artificial dyes: its health risks

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ABSTRACT
The aim of this study was to research the use of food dyes and their risks to human health. Its methodology was descriptive bibliographic review. Based on the survey, it is verified that although natural dyes are the most indicated, artificial ones are the most used by the food industry because they have high stability, uniformity in the color conferred, high tintorial power, exemption from microbiological contamination and relatively low production cost.

Keywords: Food additives, food dyes, food technology.

1 INTRODUCTION

In the last thirty years, the manufacture and preparation of food have been improved. In the past, food came from the localities where it was produced or from very close regions. Currently, most products are obtained from distant regions and, therefore, lack additives to maintain their integrity (PEREIRA et al., 2020).

In addition, the diversity and presentation of food are important requirements for the food industry. This fact has encouraged the food engineering and technology sectors to use chemical compounds to conserve, color or flavor food in order to win over more consumers (SOUZA, 2019). Therefore, it is understandable the need for the use of additives from a technological perspective in food production. However, the possible toxicological risks that can be generated by the regular intake of these substances should also be considered (SÁ, 2016).

The preservation of the natural color of food is a relevant factor for the purchase of the product, in view of the first analysis of the consumer. Before the palate, the color of food seduces people by the eyes. The logic of obtaining these products begins with vision: foods with vibrant and attractive colors can only be delicious. In a statement, appearance is the main justification for the addition of dyes in order to stimulate the acceptability of these items (ALBUQUERQUE et al., 2021).

In this bias, the general objective of this study was to perform a literature review to differentiate natural from artificial dyes, in addition to verifying the possible risks to human health that dyes may entail.

2 MATERIAL AND METHODS

The present study is based on developing a descriptive bibliographic review, in which articles of comparison between natural and artificial dyes and their health risks were researched. Because it is a procedure that allows the researcher to make known what has already been produced and published about the proposed theme.

For this study, articles published in indexed journals were selected, mainly in the databases Scielo (Scientific Electronic Library Online), ERIC (Educational Resources Information Center), Portal of Caps/MEC, BDTD (Brazilian Institute of Information in Science and Technology), Science.gov, Science Direct and Lancet Journal.

The terms used as keywords in the research were: food additives; food additives and health; food laws and additives; food technology; food additives and toxicity; food laws and dyes; food dyes and toxicity; natural dyes; artificial dyes; Alimentarius Codex.

As an inclusion criterion, we chose to research materials published between 2007 and 2021, and for the legislation on the subject no deadlines were set, due to some being old and not updated, but are in force.

3 THEORETICAL REFERENCE

Legislation on food additives

Laws are defined in a society with the function of controlling the behaviors and actions of individuals according to the pre-established principles of that society. In the case of food laws and regulations, they have an important function because of their effect in assisting consumers in making choices based on studies (MAGALHÃES, 2017).

The foundation of the bodies that are responsible for monitoring and regulating food laws are relatively recent. In Brazil, Anvisa, which is responsible for defining the national health surveillance policy, as well as standardizing, controlling and supervising products, substances and services of interest to health, can be highlighted, which includes food additives (BRASIL,2018).

ANVISA uses as a basis the standards from the Joint FAO/WHO Expert Committee on Food Additives (JECFA), the Codex Alimentarius, the European Union (EU), the Mercosur Harmonised General List of Additives and, in addition, the U.S. Food and Drug Administration – FDA. This criterion is established by Brazilian legislation - Ordinance SVS/MS n. 540/1997 - and by MERCOSUR - GMC/RES. No. 52/98.

In this context, ANVISA approves the technical regulation of Food Additives, which contain the definitions, classifications and employment of additives, . According to Item 1.2 of Ordinance No. 540 of October 27, 1997, additive is any ingredient intentionally added to food for the purpose of modifying its physical, chemical, biological or sensory characteristics, during its manufacture, processing, preparation, treatment, packaging, packaging, storage, transportation or handling, without the purpose of nourishing.

Therefore, it is worth mentioning that it is important to know the dyes, one of the sub-items that composes food additives, a topic that will be addressed below.

Dyes

Food dyes are part of one of the categories of food additives, used by the industry to color or intensify the product's own color, improving its physical characteristics, as illustrated in Figure 1 (SOUZA,

2019). The color attribute impresses the food with an important aspect related to cultural issues and affective memory of the consumer, which will influence the product's procurement (LEE et al., 2013; ROVINA et al., 2016).

Figure 1. Use of food dyes. Source: SOLOMON, 2010.

From a technological point of view, according to Albuquerque et al. (2021), one can list reasons for the use of food colorings such as the ability to restore the color of the food itself, when it is impaired in the production processes; standardize the coloring of food when it is done with the mixture of various raw materials and print color to colorless foods.

According to Resolution - CNNPA No. 44, 1977 of the National Health Surveillance Agency (ANVISA), the dyes are classified as:

- Natural organic dye - that obtained from vegetable, or possibly from animal, whose dye principle has been isolated with the use of appropriate technological process.
- Synthetic organic dye - that obtained by organic synthesis through the use of an appropriate technological process.
- Artificial dye - is the synthetic organic dye not found in natural products.
- Synthetic organic dye identical to natural - is the synthetic organic dye whose chemical structure is similar to that of the isolated active ingredient of natural organic dye.
- Inorganic dye - that obtained from mineral substances and submitted to elaboration and purification processes suitable for its use in food.

According to Technical Report No. 48 (2012), caramel dyes are classified into four classes, according to the reagents used in their production:

- Caramel I – simple (INS 150a), natural dye obtained by heating sugars at the temperature above the melting point.
- Caramel II - caustic sulfite process (INS 150b)
- Caramel III – ammonia process (INS 150c): It is the synthetic organic dye identical to the natural one obtained by the ammonia process, provided that the content of 4-methyl, imidazole does not

exceed in it at 200mg/kg (two hundred milligrams per kilo).

- Caramel IV - sulphite process - ammonia (INS 150d).

Table 1 shows the dyes with permitted use for food in the country, according to their classification.

Table 1. Food dyes for use tolerated in Brazil.

Dye	Examples
Natural organic	▪ Curcumin ▪ Cochineal; carminic acid ▪ Chlorophyll ▪ Riboflavin ▪ Caramel ▪ Medicinal coal ▪ Urzela; orcein, sulfonao orecína ▪ Carotenoids: alpha, beta, and gamma-carotene, bixin, norbixin, capsanin, capsorubin, lycopene. ▪ Xanthophylls: flavoxanthin, lutein, cryptoxanthin, rubixanthin, violaxanthin, rooxanthin, cantaxanthin. ▪ Beet red, betanine.
Artificial synthetic organic	▪ Tartrazine (E-102) ▪ Quinolein yellow (E-104) ▪ Twilight Yellow (E-110) ▪ Azorrubina (E-122) ▪ Amaranth (E123) ▪ Ponceau 4R (E-124) ▪ Erythrodrine (E-127) ▪ Red 2G (E-128) ▪ Red 40 (E-129) ▪ Blue Patent V (E-131) ▪ Indigotine (E-132) ▪ Bright Blue (E-133) ▪ Fast Green (E143) ▪ Bright Black (E-151) ▪ Marron HT (E-155).
Synthetic organic identical to natural	▪ Beta carotene ▪ β -Apo-8´-carotenal ▪ Cantaxan ▪ Caramel ammonia ▪ Ethyl acid ester β-Apo-8's 'carotene ▪ Chlorophyll and chlorophyllin cubic complex
Inorganic (pigments)	▪ Calcium carbonate ▪ Titanium Dioxide ▪ Iron oxide and hydroxide ▪ Aluminum, Silver, Gold

Adapted from: BRASIL, 1997; BRASIL, 1999.

These dyes are periodically reevaluated and their toxicity has been evaluated by JECFA (Joint Executive Committee of Additive Specialists) since 1972. In this same document, ANVISA guarantees that they do not pose health risks, as long as they do not exceed the IDA (Acceptable Daily Intake).

Some of the items to be analyzed, in order to verify potential harm to human health, generated by an additive, are its toxicity, solubility (in water and /or alcoholic solvents), chemical reactivity with other food components, stability as to light, heat, humidity and shelf life time. (MAGELLAN, 2017).

In this bias, it is worth emphasizing the importance of knowing more about artificial and natural dyes, which are the focus of the largest discussions in the food industry.

Natural dyes

Among the main sources for obtaining natural dyes (Figure 2) are plants (leaves, flowers and fruits), animals (insects) and microorganisms (fungi and bacteria) (NESPOLO, 2015).

Figure 2. Natural food dyes. Source: SOLOMON, 2010.

Although natural dyes have disadvantages (low stability and high cost) compared to artificial dyes, natural ones have been used for years without evidence of damage to health. Therefore, despite the disadvantages, the substitution by natural dyes is gradual in the food industry, because they give the product a natural aspect, which increases consumer acceptance (NESPOLO, 2015).

According to Albuquerque et al. (2021), annatto, cochineal carmine, curcumin, anthocyanins and betalains are world considered the main natural dyes used in the food industry. Thus, natural raw materials have been increasingly researched, which demonstrates their evolution in the globalized market. The following is information on the above-mentioned dyes.

Annatto

Annatto is present in the group of vegetables and is considered one of the most used by the Brazilian industry, representing about 90% of the natural dyes used in Brazil and 70% in the world. Its pigment is extracted from the outer layer of the seeds of the Bixa orellana plant, being the source of bixin carotenoid (FABRI; TERAMOTO, 2015).

Its color varies from yellow to orange, depending on the pH of the medium. It can be used in juices, gelatins, sausages, margarines, biscuits and others. Its color is stable and intense, belonging to the group of carotenes (BARROS; BARROS, 2010).

Carmine / Cochineal / Carminise Acid

The production of carminic acid is the main constituent of the cochineal (responsible for the tintorial power of the dye), extracted from desiccated females of *insects of the species Dactylopius coccus Costa*. The term cochineal is used to describe both dehydrated insects and dye derived from them (TITO; ZUNI, 2019).

Referring to its coloration, in acid pH acquires the color orange, becoming red in the range of 5.0 to 7.0 and blue in the alkaline region. It has low solubility at reduced pH, is considered quite stable to heat and light, resistant to oxidation and does not undergo significant changes by the action of sulfur dioxide (TITO; ZUNI, 2019).

Carmin has application in meat products (sausages, surimi and red marinades), some types of preserves, gelatins, ice cream, dairy products and various desserts (TITO; ZUNI, 2019).

Curcumin

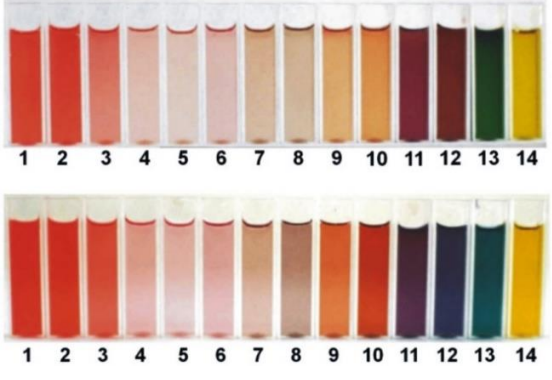
Curcumin is obtained through turmeric rhizomes (Long Turmeric L.). It is the result of three types of extracts, the essential oil, oil-resin and curcumin. Curcumin extract contains the responsible for the dye power is produced by the crystallization of the oil-resin and presents purity levels around 95% (SUETH-SANTIAGO, 2015).

Its coloring reaches the bands of lemon yellow color, in acidic medium, and orange, in basic medium. As for its stability, it is stable to heating and sensitive to light, a factor that usually limits its use in food. It is applied as a pickle stain and as an ingredient in mustard sauces (SUETH-SANTIAGO, 2015).

Anthocyanins

Anthocyanins are pigments found only in vegetables and are dominant in many fruits and flowers. They make up the largest group of water-soluble pigments in the plant kingdom, being found in greater quantity in angiosperms. In addition, they are able to strongly absorb light in the visible spectrum region, conferring a multitude of colors between orange, red, purple and blue, depending on the pH of the medium in which they are shown as illustrated in Figure 3 (SCHAFRANSKI; RODRIGUES, 2017).

Figure 3. Staining obtained with antiocyanins from pH. Source: SOLOMON, 2010.



In addition to pH, the color of anthocyanin extracts depends on other factors such as concentration, type of solvent used for its extraction, temperature, pigment structure, presence of substances capable of reversible or irreversibly reacting with anthocyanin, among others. However, pH is certainly the most important factor with regard to staining (ALBUQUERQUE et al., 2021).

Anthocyanins can be obtained from grape skin extracts. The peels are by-products of the grape processing industry for the manufacture of wine and grape juice and have aroused interest for the use in the commercial production of anthocyanins due to the low cost and high dye content (CORRÊA et al., 2019).

The main disadvantage of the use of pigment as a dye is related to degradation suffered during vegetable extraction, processing and storage of food. The stability of anthocyanins is higher under acidic conditions, but degradation by various mechanisms can occur, starting with the loss of color, followed by the appearance of yellowish staining and formation of insoluble products. The color stability of anthocyanins is dependent on the structure and concentration of pigments, as well as factors such as pH, temperature and the presence of oxygen. Degradation can be influenced by enzymes, ascorbic acid, sulfur dioxide, metal ions (iron), in addition to the factors mentioned above (SCHAFRANSKI; RODRIGUES, 2017).

Betalains

Betalains are compounds similar to anthocyanins and flavonoids, being hydrosoluble pigments and divided into two classes: Betacyanin (responsible for the coloration of red to violet) and betaxanthin (responsible for yellowish staining) (ALBUQUERQUE et al., 2021).

The main raw material for obtaining it is beetroot, which is subjected to laboratory processes to obtain the colouring powder. Its use in the food industry applies to various types of beverages and foods such as juices and confectionery products, respectively (ASTORGA, 2019).

The instability of their color is influenced by pH, thus, they are stable between pH 4 and 5 and reasonably stable between pH 5 to 7, where reddish coloration is preserved. In addition to these factors, water, light and oxygen activity also affect pigment stability (CORRÊA et al., 2019).

Artificial dyes

Artificial dyes are a class of additives that have no nutritional value, being added in foods and beverages for the sole purpose of assigning color, making them attractive. For this reason, from the perspective of health, there is no recommendation for the use of artificial dyes, and their use is justified, almost completely, for commercial and technological reasons (AZEREDO, 2017).

Some advantages are inherent to artificial dyes, according to Corrêa et al. (2019), most of them have high stability (light, oxygen, heat and ph), uniformity in the color conferred, high tintorial power, exemption from microbiological contamination and relatively low production cost. However, the use of artificial dyes has been periodically questioned according to the toxicological aspects of these substances.

Health risks

Artificial dyes are not completely harmless to health and are constantly being investigated regarding their relationship with the risks of adverse reactions that may arise by consumers (PEREIRA, 2020).

There are numerous harmful reactions that artificial dyes may present, however, the most remarkable and potentially severe, is related to tartrazine (yellow FD&C no. 5), considered an azo dye with chemical structure similar to that of benzoates, salicylates and indomethacin that can determine severe crossreaction with these drugs. In addition to these effects, bronchospasm, hives, allergic reactions in aspirin-sensitive and asthmatic people, and angioederma that can be triggered in hyperkinesia hyperactive patients (AZEREDO, 2017) may also occur.

The most investigated dyes currently are those of the Azo group (tartrazine yellow, twilight yellow and red 40). This fact is due to the possible mutagenic and carcinogenic effects of these dyes (SOUZA, 2019).

The table below describes some of the most consumed artificial dyes in the world and their respective health risks.

Table 2. Most consumed artificial dyes in the world and their risks to human health.

Dyes	Origin	Application	Adverse effects
Yellow Twilight	Synthesized from coal tar paint and azoic paints.	Cereals, candies, caramels, toppings, syrups, dairy products, gums.	Azo ink causes allergy, urticaria, angioedema and gastric.
Bright blue	Synthesized from coal tar paint.	Dairy products, candies, cereals, cheeses, fillings, gelatins, liqueurs, soft drinks.	May cause hyperactivity in children and eczema and asthma.
Red Erythrothesin	Coal tar ink.	Powders for gelatins, dairy products, soft drinks, jams, etc.	Contains 557 mg of iode per gram of product, can cause increased thyroid hormone in the blood, in levels to

			cause hyperthyroidism.
Indigotine (dark blue)	Coal tar paint.	Mason gums, yogurts, candies, caramels, drinks, etc.	May cause nausea, vomiting, hypertension, allergy, and breathing problems
Yellow Tartrazine	Coal tar paint.	Dairy products, liqueurs, fermented, cereal products, fruits, yogurts, etc.	Allergic reactions in people sensitive to aspirin and asthmatics. Causes insomnia in children and disorder of the gastrointestinal flora.

Source: FURTADO, 2007.

Regarding the harms of artificial dyes, a study conducted by McCann et al. (2007) concluded that the consumption of artificial dyes causes hyperactivity in children, which can cause impulsivity and inattention, impairing their learning, especially at school. According to Schumann, Polonium and Gonçalves (2008), children belong to the group most vulnerable to adverse reactions of food additives, because they do not yet have enough criticality for the choice of foods and do not have control of food intake rich in additives.

4 RESULTS AND DISCUSSION

From the study, it is concluded that artificial dyes are still widely used by the food industry, in relation to natural dyes. However, there are requirements regarding the use of dyes for food purposes, and evaluations are required for their toxicity, solubility (in water and/or alcoholic solvents), chemical reactivity with other food components, stability regarding light, heat and humidity and shelf life.

Regarding natural dyes, annatto, cochineal carmine, curcumin, anthocyanins and betalains are considered the main used in the food industry worldwide. Thus, natural raw materials have been increasingly researched, which demonstrates their evolution in the globalized market.

Although natural dyes are the most suitable for consumers, artificial ones continue to be the most used by the industry, due to the majority presenting high stability (light, oxygen, heat and ph), uniformity in the color conferred, high tintorial power, exemption from microbiological contamination and relatively low production cost.

Research has shown that the consumption of artificial dyes above AI presents several health risks, causing reactions such as nausea, vomiting, hypertension, allergy, respiratory problems, problems in the intestinal flora and tumors. In addition, tartrazine has been pointed out as the most harmful among artificial dyes, and can trigger hyperactivity in children since attention deficit, since it is present in foods most consumed by this group such as candies, ice cream, gelatins, gum, yogurts, cereals, liquors and dairy products.

5 CONCLUSION

Given the above, it is important to reinforce the need to create strategies to reduce the use of artificial dyes in food products, in addition to, at the same time, inventive the use of natural dyes in food production. For this, it is necessary to develop public policies and programs aimed at health promotion through healthy eating, with the least possible amount of food additives in their composition. In this way, it will be creating relevant guidelines for the whole population to have a better quality of life.

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