

CHEMICAL COMPOUNDS IN THE ONLINE ENVIRONMENT: QUO VADIS?

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Abstract. *Even though the Internet is an enormous online library, discrimination between the accurate, scientific data and misleading information can be a serious issue even for a well- trained person. Unfortunately, a plethora of false information related to the chemical compounds with major impact on our lives is distributed on online environment. The main purpose of this paper is to review a few of the most encountered urban myths related to the "dangerous, carcinogenic, toxic" substances or, on the contrary, "panacea compounds". Thus, the paper does analyze the popular (unconfirmed) facts and statements versus scientific evidence covering hot topics such as parabens, monosodium glutamate (MSG), Saccharin, amygdalin and Laetril, resveratrol, and rheosmin (raspberry ketone). Furthermore, the paper emphasizes the role of the high – school teachers in ensuring that students do access the most relevant and valid sources of information, while providing specific tools to discriminate between accurate, scientific data and false and dangerous statements with negative consequences from the educational perspective and beyond. Last but not least, the paper highlights the importance of using reliable sources of information from well-established institutions such as the EFSA (European Food Safety Authority, www.efsa.europa.eu), EMA (European Medicine Agency, <http://www.ema.europa.eu>), FDA (Food and Drug Administration, www.fda.gov), the EPA (Environmental Protection Agency, www.epa.gov), the IARC (International Agency for Research on Cancer, www.iarc.fr), the ANM (National Medicines Agency, <http://www.anpm.ro>), WHO (World Health Organization, www.who.int), EMA (European Medicine Agency), Mayo Clinic.*

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1. INTRODUCTION

The Internet can be understood as technology with an important impact on our lives, affecting the life quality and, potentially, being an important factor in knowledge development. At the beginning of the Internet era, the access was rare, but has grown rapidly. For example, in 1995, only 0.04 percent of the world's population had access, while of June 2017, this percent raised to 51% [1-4]. Among significant benefits, such as electronic

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communications, online shopping, online banking, implementation of the Internet of Things concept, to name just a few of them, the online environment is a fast and accessible information tool, used by a huge number of people [5]. Nowadays, the educational process cannot be conceived beyond the use of Internet information resources [6-9].

However, in many cases the quality of the information provided by the online environment lacks accuracy, objectivity, believability, relevance and value-added point of view [10].

Thus, the overall accessibility of these vast and mixed resources has not been unencumbered by risks and challenges.

This is a consequence of the fact that anyone with access to the Internet can posts and further disseminates opinions, including misleading information with alleged value of truth, although it has no recognized competencies in the field. In many cases, these mistaken statements, through repetitive and obsessive dissemination, become "well-known" and then, as an unfortunate consequence, "reliable" facts.

Even though Internet is in fact a huge online library, the issue of selecting the right and appropriate information cannot be neglected.

One of the most important concerns for educators is how could their students discriminate and finally, identify the correct sources of information.

According to National Education Association (www.nea.org) there are university studies which found that only 27% of the websites used for study by students can be categorized as reliable sources of information [11].

Subjects like drugs, cosmetics, the quality of air and food are deeply discussed by people in all levels, and via all communication media, having a major impact on our lives. As they are strongly correlated to the notion of molecule, chemistry seems to be a vulnerable domain, favourable to the launch of public concerns, shocking unconfirmed facts or simply "fake news"

The main purpose of this paper is to analyze the most encountered urban myths related to the "dangerous, carcinogenic, toxic" substances or, on the contrary, to the "*panacea* compounds".

Furthermore, the paper emphasizes the role of teachers in explaining their students the importance of checking the validity of the information sources, while providing advice and tools to discriminate between accurate, scientific data and false and dangerous statements, with negative consequences from the educational perspective.

2. CHEMISTRY AND THE INTERNET

The huge potential of the Internet has inspired the development of new forms of learning in chemistry. Today, the Web-based technologies offer access to an enormous amount of information, so one could spend the whole life reading and investigating the amazing online world of molecules and their chemistry.

There are so many chemistry databases, reference materials, courses prepared by prestigious universities, online paper collections, publications, images and video materials (animations of chemical processes which otherwise cannot be described in simple words), multimedia teaching material for lab exercises, development of virtual instruments (e.g., a virtual gas chromatograph or IR spectrometer), blogs and simple personal opinions, all making it very difficult for the user to decide where to start.

The choice becomes more complicated when the information about a particular subject is contradictory, leading to directly opposite conclusions. The present paper does not refer to

niche subjects of a disarming scientific complexity. For the vast majority of cases, discussions are focused on trendy subjects who capture the interest of the general public, and where everyone can express their opinion, advice and/or declare himself/herself specialist in the domain. Two major trends that have outlined over time were identified. On the one hand, there are chemical compounds that are categorized as avoidable enemies, potent, dangerous, potentially fatal poisons. On the other hand, many other substances have the reputation of true panacea, possessing amazing medicinal and pharmacological properties, capable of curing any disease.

For instance, the so-called “carcinogenic potential” of parabens [12] and saccharin [13], the “miraculous” effects of amygdaline (vitamin B17) [14], cesium chloride [15] and 714-X [16] in cancer treatment, the danger of “intoxication” with methanol in the case of consumption of artificial sweetener Aspartame [17], avoiding “contaminated” fruits that have been artificially ripened in the ethylene controlled atmosphere, are just a few of the hot topics which circulate and are strongly debated in online medium [18].

In order to demonstrate how the information can be distorted, how differently the same chemical compounds and their properties can be presented and evaluated and what a negative consequence can be given to misleading information assimilation, this paper will present some of the cases representative of the subject in question. For illustrative purposes, the original text of the source (in our translation, where applicable) was maintained.

2.1. PARABENS: WHAT ARE THEY? AND ARE THEY REALLY HARMFUL?

Parabens are esters of *p*-hydroxybenzoic acid, usually named by the type of the alkyl radical, followed by the paraben suffix: for example, methylparaben (E number E218), propylparaben (E216), heptylparaben (E209) etc.

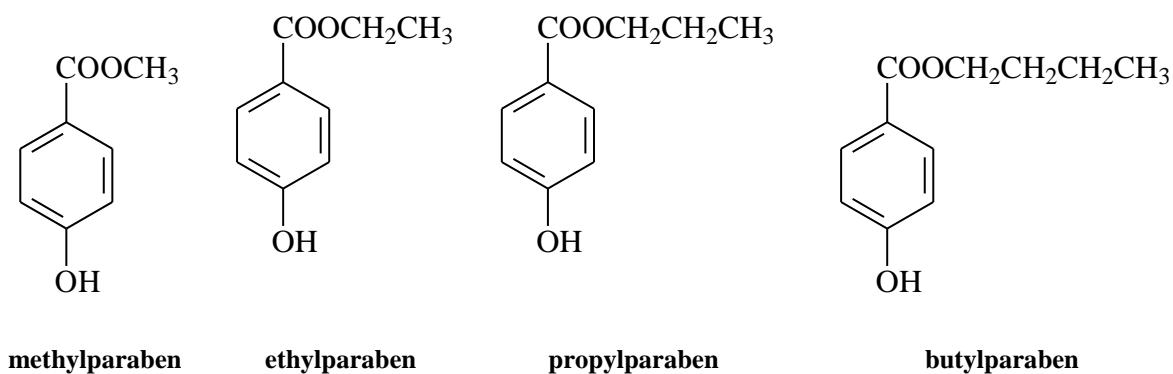


Figure 1. The structure of the methyl, ethyl, propyl and butylparaben.

The classical synthesis of parabens consists in the esterification of *p*-hydroxybenzoic acid with ethanol in acid catalysis:

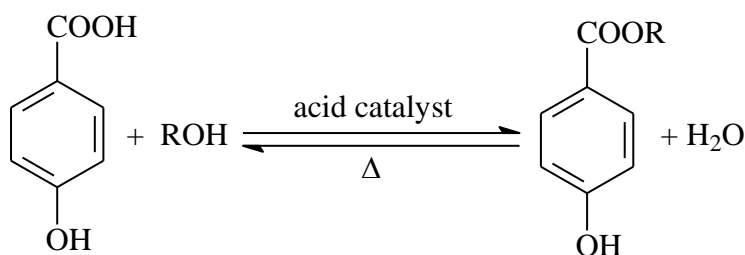


Figure 2. Chemical reaction for parabens synthesis.

Parabens are widely used as preservatives, both in cosmetics (lotions, makeup, shampoos, creams, and toothpastes), and in the food industry, generally active against yeasts and molds. Usually, to achieve satisfactory results, a mixture of several parabens and other preservatives is used to provide the products with an antimicrobial spectrum as wide as possible [19].

However, there are a lot comments which circulates on the online media regarding the adverse effects of parabens. Just a two example are presented below:

- “Parabens (Methylparaben, Ethylparaben, Propylparaben, Butylparaben, Isobutylparaben or Phenonip) are potentially carcinogenic preservatives and are used in most care products (deodorants, shower gels, shampoos, lotions, make-up products). Affects estrogen hormonal balance and contributes to the development of breast cancer. Because they raise the level of estrogen in the blood, parabens can affect both men's health and reproductive functions. The risk of cancer or infertility can even stand in the antiperspirant you use daily” [20].
- “Parabens: are preservatives that quickly penetrate the skin, have estrogen-like effect and are criminalized for breast cancer. Some parabens can disrupt the endocrine system and can cause reproductive and developmental disorders” [21].

Furthermore, the safety of parabens was also questioned by a study published in the *Journal of Applied Toxicology* which claims that parabens have been detected in breast tumors [22]. Knowing the estrogenic activity of parabens, the conclusion of the study was alarming (the effect of estrogen in breast cancer is known, also). The experiment raised interest and controversy in the scientific community. For example, it did not prove a direct correlation between the presence of parabens in the affected tissue and the occurrence of cancer. It also did not provide information about the possible existence of parabens in healthy tissues in the proximity of the tumor [23, 24]. Moreover, there have already been studies on the low estrogenic activity of parabens (for instance, butylparaben has an estrogenic activity of 10,000 to 100,000 times less than estradiol) [29, 30].

As mentioned in the document named “Opinion on parabens” published by the European Commission and Directorate-General for Health & Consumers: “After thorough study of the available knowledge, the SCCP concluded that there was insufficient data to establish a link between the use of underarm cosmetics and breast cancer (SCCP/0874/05). Meanwhile, no additional data providing evidence to the contrary were encountered” [28]. Finally, although there were suspicions, it can be concluded that there is no scientific evidence to support any link between the use of parabens and the occurrence of any type of cancer [25].

In the European Union it is allowed to use parabens and their salts in cosmetic products, with a concentration limit of 0.4 % (w/w) for each and 0.8 % (w/w) in total for the paraben mixtures. In addition to these regulations, the use of butyl and propyl parabens is limited to a maximum of 0.14 % (w/w) for the sum of the two compounds.

At the same time, according to the official position of FDA (Food and Drug Administration) parabens are safe and effective preservatives for the cosmetic industry. Paradoxically, parabens along with many other chemicals with ability to mimic estrogen are found in "natural" products such as beans, cherries, blueberries, carrots. Estrogenic activity of parabens is the main argument against the use of parabens, but the sum of substances from plant products has an estrogenic effect much more pronounced compared with that of the parabens used in cosmetic products, in small amounts [26,27].

2.2. MSG - WHAT YOU NEED TO KNOW?

Monosodium glutamate (MSG) (Fig. 3) is a compound naturally produced in human bodies and is found in many foods, such as cheese, carrots, eggs, tomatoes, mushrooms, and other vegetables. MSG is widely used in the food industry as a flavor enhancer [31].

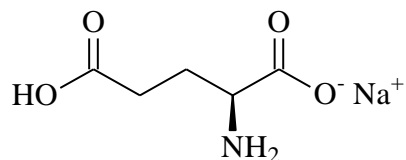


Figure 3. The structure of monosodium glutamate.

Sodium glutamate's ability to enhance flavor was discovered in 1908 by Kikunae Ikeda, a professor at Tokyo Imperial University, who isolated monosodium glutamate from marine algae *Laminaria Japonica* [32]. The traditional methods of synthesis of monosodium glutamate are acid or basic hydrolysis of proteins, the raw materials being marine algae, wheat gluten, soybean, etc. Modern methods of synthesis are fermentative processes in the presence of *Micrococcus glutamicum* bacteria [33].

Although it has been used for over a hundred years as a flavor enhancer in various types of foods, fruits, legumes, juice concentrate, monosodium glutamate remains a controversial chemical additive, its toxicity being one of the hottest topic discussed. Some of the comments which promotes the adverse effects of MSG are listed below:

- “Many nutritionists call monosodium glutamate a "silent killer" more dangerous for health than alcohol, nicotine and some types of drugs once consumed in large quantities” [34].
- “There are a growing number of people who report immediate, adverse reactions within minutes eating MSG. Perhaps you’re one of those people? Or, maybe you know someone who is sensitive? Typical MSG complaints include: burning sensations of the mouth, head and neck, weakness of the arms or legs, headaches or allergic-type reactions with the skin” [35].
- “Monosodium glutamate is a flavor and taste enhancer that can lead to obesity, diabetes and hypertension. Consuming this ingredient as a result of intake of fast-food foods, the body tends to experience the hunger constantly. Monosodium glutamate is able to "trick" your brain into believing you ate something extremely satiating. In fact, you only ingest "empty" calories of zero nutritional value. Where is this ingredient found? Many of the powders with which sauces are prepared, but minced meat contains glutamate” [36].

However, despite of these comments and opinions, the FDA classifies MSG as a Generally Recognized as Safe (GRAS) substance. According to Food and Drug Administration: "Although many people identify themselves as sensitive to MSG, in studies with such individuals given MSG or a *placebo*, scientists have not been able to consistently trigger reactions" [37]. Furthermore, the specialists of the Mayo Clinic, Rochester (ranked as the #1 overall hospital in the United States by U.S News & World Report 2016-17) posted the following comments about the MSG: “Over the years, the FDA has received many anecdotal reports of adverse reactions to foods containing MSG. These reactions — known as MSG symptom complex — include: headache, flushing, sweating, facial pressure or tightness, numbness, tingling or burning in the face, neck and other areas, rapid, fluttering heartbeats

(heart palpitations), chest pain, nausea, weakness. However, researchers have found no definitive evidence of a link between MSG and these symptoms” [38].

EFSA (European Food and Safety Authority) has reassessed the safety of using glutamates used as food additives by setting a daily dose of 30 mg / kg body weight for all six glutamate additives. This level of safety is the highest dose that does not produce adverse effects according to animal toxicity studies [39].

Furthermore, the role of glutamic acid and glutamates is reevaluated as substitute for salt to reduce sodium content in specific industrialized foods to levels considered safe, as the World Health Organization (WHO) recommends for adults a daily intake of not more than 5 g NaCl (less than 2 g of sodium) [40].

In addition to monosodium glutamate, there are other structural care products that are used as additives in food industry: monopotasic glutamate (E622), calcium glutamate (E623), ammonium glutamate (E624), magnesium glutamate (E625).

2.3. SACCHARIN, ALWAYS A HOT TOPIC

Saccharin is a white, crystalline solid, synthesized in 1879 by a chemist working at at John Hopkins University's, on its name Constantin Fahlberg:

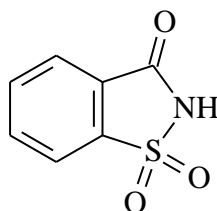


Figure 4. The chemical structure of saccharin.

Saccharin is the oldest sweetener, with a sweetening power hundreds of times higher than sucrose, being used as an additive (E954) in a wide variety of products: cakes, jams, dairy products, soft drinks, candies, oral hygiene products (toothpaste, mouthwash), chewing gum, medicines etc. [41].

Toluene is the starting material in the traditional saccharine synthesis process, the Remsen-Fahlberg method [42]:

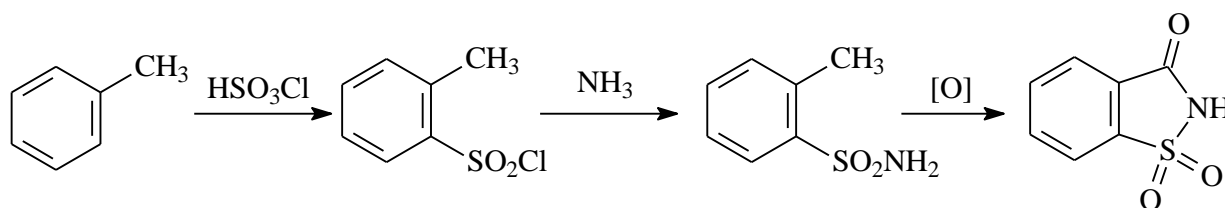


Figure 5. The Remsen-Fahlberg synthesis of toluene.

Being poorly soluble in water, it is usually used in the form of sodium or calcium salts (for those with hypo-status regimen). Due to the unpleasant residual taste (bitter, metallic), saccharin is often used in combination with other sweeteners. Although it has been in use for over 100 years, there have been periods in which the safety of saccharin consumption has been questioned.

Moreover, there is a huge number of websites which claims that saccharin is harmful, well-known carcinogen, and a real health bomb:

- “In 1879, when it was discovered, saccharin was considered a solution for people who suffer from diabetes. But further research has shown that health effects are among the most dangerous, going to cancer” [43].
- “Saccharin and other sugar substitutes, a health bomb” [44].
- “500 times as sweet as sucrose and with extremely low-calorie content, this synthetic sweetener can irritate the gastrointestinal tract and the kidneys, and is forbidden to pregnant and nursing women. Saccharin consumption in prepared dishes and beverages must not be greater than 0.015%. According to some data from specialty studies, saccharin, consumed in large quantities for a long time, may cause the onset of carcinogenic diseases. The most worrying fact is the high incidence of bladder, prostate and prostate cancer in consumers” [45].

Saccharin has been scrutinized intensely for decades. For example, in the early 1970s, a study was published that highlighted a possible link between saccharin consumption and bladder cancer in rats [46]. Concerns have been resolved later, numerous studies invalidating the carcinogenic potential of saccharin. Compared to human urine, rat urine has a high pH, high calcium phosphate concentration, and increased protein concentration. In combination with saccharin, this unique urine composition produces microcrystals that damage the bladder tissue.

Overproduction of cells (as response to the organism) leads to the formation of tumors. Since more than 30 human studies demonstrated that these conditions are not met by human urine, it is clear that there is no reason to worry. Consequently, the EFSA, FDA, EPA, and other such bodies consider saccharin consumption to be safe [47, 48]. Actually, former FDA director Bernard Oser fully confirmed the safety of saccharin consumption, stating that there is no chemical additive to be tested in a larger number of laboratories for such a long period of time on a number of so diverse subjects (humans and animals) that are so innocuous [49].

As could be seen, on the one hand there are molecules that, despite being in the composition of millions of consumer products used by a huge number of people, have a bad reputation and are considered true poisons by many Internet users. On the other hand, there are a lot of chemical compounds that have been promoted to treat or prevent many diseases in humans (especially for cancer) but which lack scientific and medical evidence of effectiveness, many of them being toxic. Some examples are described below:

2.4. AMYGDALIN AND LAETRIL, PROBABLY THE MOST FAMOUS FAKES IN ALTERNATIVE CANCER TREATMENT

Amygdalin, a naturally occurring chemical compound, became famous for falsely being promoted as a cancer treatment. It is found in many plants, especially in the seeds of apricot, bitter almonds, and apples.

A lot of anecdotal stories about Amygdalin (Fig. 6) and semisynthetic form of amygdalin, named Laetrile (Fig. 7) can be found on websites which encourage the public to prevent and treat cancer using these two compounds. Both have been promoted under the misnomer vitamin B₁₇ [50].

Some of them are listed below:

- “Can Prevent and Treat Cancer Easily! According to studies, the required daily dose of vitamin B₁₇ is 3-5 capsules a day. Dr. Ernst Krebs was a researcher dedicated to the research of B₁₇ strain from apricot kernels. After years of study, he was convinced of

- the therapeutic value of vitamin B17 against cancer cells. According to this, this vitamin does not have any harmful effects on the body, as other studies suggest” [51].
- “Vitamin B17 was banned for cancer treatment 35 years ago, even though many scholars have argued that if a person were to consume this vitamin daily, they would not develop cancer, according to the author of that volume. According to him, pharmaceutical giants and the US Department of Health have exerted tremendous pressure on the Food and Drug Quality Control Division, which has declared illegal the sale of B17 vitamin, together with the information on its therapeutic effects against cancer” [52].

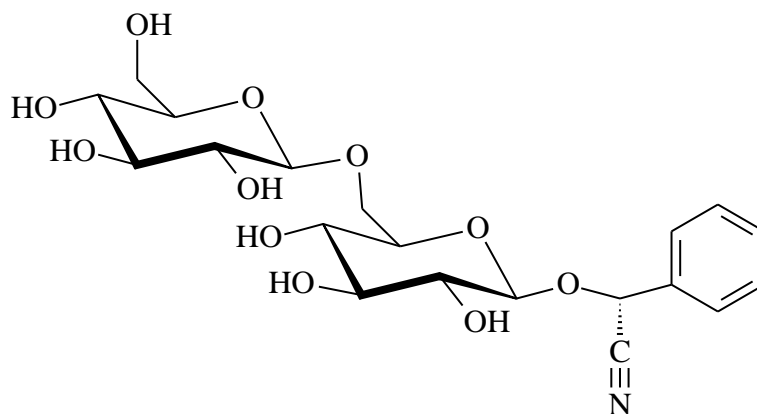


Figure 6. The structure of Amygdalin.

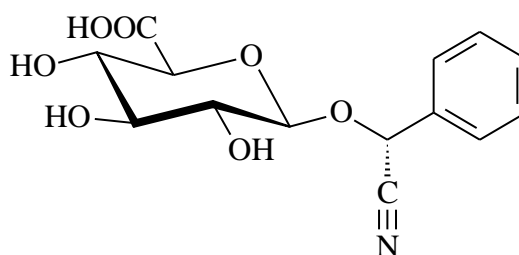


Figure 7. The structure of Laetril.

But there is no scientific evidence that Amygdalin or Laetril can work as treatment for cancer or any other medical condition [53]. The agencies responsible for medicine regulation like EMA (European Medicine Agency) or U.S. Food and Drug Administration (FDA) have not approved Laetril as a treatment for cancer or any illness. Furthermore, both compounds are toxic, due to the cyanide content.

Besides Amygdalin and Laetril, there are many other examples of natural or synthetic chemical compounds, more or less known that have become famous on the Internet as a means of preventing and treating cancer. Examples of such types of molecules include caesium chloride, alkaline water [54], ellagic acid [55], germanium [56], etc. None of these compounds could prove their anticancer properties. Moreover, many of them are toxic, well-known for their detrimental effects.

2.5. RESVERATROL, RED WINE, CARDIOVASCULAR HEALTH AND CANCER: WHAT'S THE STORY?

Resveratrol (3, 5, 4'-trihydroxy-*trans*-stilbene), a natural type of polyphenolic compound, is produced by more than 70 plants (peanuts, grapes, blueberries, cranberries, etc.) in response to some different kinds of stress (sunlight, ozone, heavy metals). It is also synthesized in response to infection by the pathogen *Botrytis cinerea* [57, 58].

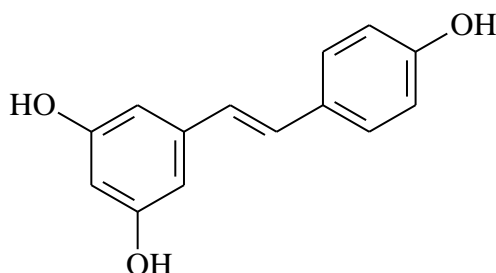


Figure 8. The structure of resveratrol.

Due to the fact that polyphenols which are found in grape's skin and red wine have a pronounced antioxidant character and may help protect the lining of blood vessels in heart, resveratrol has become the subject of interest in the last decades.

A lot of comments and statements about the health benefits of resveratrol (taken mostly as supplements) can be found on the Internet. For instance:

“Resveratrol can be used:

- during anti-tumor therapy prevents and treats cancerous diseases (in combination with traditional treatments);
- increasing immunity, against biologic stress;
- it is used against heart disease, arteriosclerosis- prevention and treatment;
- improves microcirculation in tissues and organs, prevents and treat varices and thrombosis
- helps rehabilitation the body after surgery;
- malignant tumors, cervical ectropion, uterine fibroids, breast nodules;
- in the case of allergic diseases, for example asthma;
- in diabetes and hypertension, in treating and preventing retinal damage;
- people living in a polluting environment;
- is well known for its anti-aging cellular properties” [59].

“Resveratrol influences gene expression and has shown to provide anti-aging benefits. Mitochondrial oxidative stress and consequential free radical reactions contribute to the advanced aging of cells. Conversely, longevity is associated with resistance to oxidative stress. Resveratrol is able to put a temporary hold on the cell cycle by pausing at a stage which allows for DNA repair. As a consequence, a greater number of damaged genes are fixed and fewer mistakes continue to replicate in our cells” [60].

As may be observed, resveratrol seems to act as a true panacea. At first glance, many diseases can be cured by simple supplementation of Resveratrol. This is the reason why there are plenty of companies that commercialize resveratrol supplements.

The question is: does resveratrol really work? Several studies found no benefits from resveratrol in preventing heart disease [61, 62]. According to Mayo clinic: “More research is needed to determine if resveratrol lowers the risk of inflammation and blood clotting” [63].

Indeed, researchers haven't found any harm and side effects in administration resveratrol supplements. However, our body is not able to absorb most of the resveratrol found in the supplements. Thus, despite an aggressive advertising expert do not advise taking resveratrol supplements for antiaging or disease prevention.

2.6. RASPBERRY KETONE AS A MIRACLE WEIGHT-LOSS SUPPLEMENT. DOES IT REALLY WORK?

Rheosmin or raspberry ketone, 4- (4-Hydroxyphenyl) butan-2-one (Fig. 9) is one of the compounds responsible for raspberry flavor (1-4 ng compound / kg of fruit). Other natural sources of raspberry ketone are blueberries and blackberries [64].

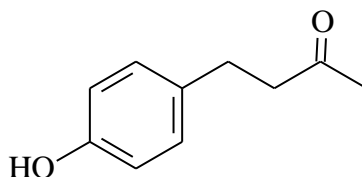


Figure 9. The structure of raspberry ketone.

It is considered to be one of the most expensive flavors, being widely used in both the food industry and the cosmetics and perfume industry. Lately, raspberry ketone has become a very trendy weight loss supplement due to a possible efficacy in the treatment of overweight/obesity. The proponents of raspberry ketone claim that this molecule can really protect against weight gain and fatty liver [65]:

“Raspberry Ketone is a concentrated raspberry extract that tends to become an important player in the fight against fats. It is a natural product recommended by weight loss specialists. He acts on several paths in weight loss:

- The high level of ketone in the body stimulates the production of adipopectin, a hormone responsible for controlling appetite and fat levels.
- Accelerating fat burning by turning them into energy.
- It favors the removal of fats from the fat layers.
- Inhibit absorption and accumulation of fat in the body.
- Also, ketone has the role of increasing norepinephrine levels, a hormone that induces lipolysis, in other words decomposition of fat cells.
- It has antioxidant properties, remineralizing effects, increases resistance to infections.”

Although it has long been popularized by more or less authorized specialists, there is currently no evidence that raspberry ketone supplements can cause weight loss in humans. There are just a few examples in order to emphasize how the huge amount of misleading information are distributed and propagated on Internet. False information about different chemical substances can be very dangerous. Besides assimilation of incorrect information, one can get to much more serious issues, such as treating a disease using ineffective treatments, or even worse, very toxic substances. For this reason, the role of educator has a crucial importance. There are several steps which must be included in training of the students:

- First of all, he must inform and prevent the students about this phenomenon which continues to grow;
- Students will be advised to avoid information on blogs. Usually, these statements are simple personal opinions, more or less accurate;
- The student must know that the process of learning must be initiated from credible sources of information (courses, books, recognized scientific literature). Thus, he will

- be able to discriminate between false and accurate data which are found on the Internet.
- The educator must emphasize the importance of using reliable sources of information from well-established institutions such as the Food and Drug Administration (FDA), the EPA (Environmental Protection Agency), National Cancer Institute (NCI), the International Agency for Research on Cancer (IARC), the National Medicines Agency, EMA (European Medicine Agency), Mayo Clinic.
 - Last but not least, the educator will highlight that even the information appearing on the above-mentioned institutions' websites is constantly updated.

3. CONCLUSIONS

The aim of this paper is to review a few of the most propagated “fakes” related to the “dangerous, cancerigen, or toxic” substances or, on contrary, compound which are effective in treatment of cancer or any other medical conditions. Thus, the paper presents the stories (pros and cons) about parabens, monosodium glutamate (MSG), saccharin, amygdalin and Laetril, resveratrol, and rheosmin (raspberry ketone).

Furthermore, the paper highlights the role of the educator to show the importance to check the validity of source of information and to offer tools in order to discriminate between accurate, scientific data and false and dangerous statements. Last but not least, the paper highlights the importance of using reliable sources of information from well-established institutions such as the Food and Drug Administration (FDA), the EPA (Environmental Protection Agency), the International Agency for Research on Cancer (IARC), the National Medicines Agency, EMA (European Medicine Agency), Mayo Clinic.

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