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The price of “health”: Herbalife[®] and Juice Plus+[®] products under study

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Abstract:

The popularity of dietary supplements is increasingly on the rise: people are turning to them both for the purpose of weight loss and to maintain good health, so that in recent months and with the influence of the Covid-19 lockdown, dietary supplement companies have multiplied their profits, with Herbalife® and Juice Plus+® among the biggest benefited, yet in both cases seems to be that the traders do not have the necessary knowledge on nutrition. The aim of this review is therefore to analyse the best-selling products of these companies in terms of their components and the available scientific evidence. The articles reviewed were obtained by a search through various databases, with specific selection criteria for each component and its supposed health benefits, giving preference to the most recent publications. Results show that some of these supplements' ingredients do have scientific evidence supporting them (as is the case of coffee, green tea and, to a lesser extent, Aloe Vera), but others lack of significant evidence to attribute their claimed benefits (as is the case of substitute shakes, vitamin and omega supplements and glucomannan); moreover, adverse effects related to the consumption of these products have been reported and, in some cases, these had led to serious health consequences. In conclusion, it can be stated that the consumption of Herbalife® and Juice Plus+® supplements do not provide benefits in terms of health, and effective measures and policies are needed to promote healthy lifestyles as the main important measure to adopt by the whole population.

Resum:

L'ús de suplementes dietètics està cada vegada més de moda: la gent confia en aquests productes tant amb l'objectiu de perdre pes com de mantenir una bona salut, de manera que durant els últims mesos i amb la influència del confiament per la Covid-19, les empreses dedicades a comercialitzar aquests suplementes han multiplicat els seus beneficis, sent Herbalife® i Juice Plus+® dues de les més beneficiades, malgrat que en ambdós casos els comerciants no acostumen a disposar dels suficients coneixements necessaris en nutrició. Així doncs, l'objectiu d'aquesta revisió és analitzar els productes més venuts d'aquestes companyies en funció dels seus components i l'evidència científica disponible al respecte. Els articles revisats s'han obtingut mitjançant la cerca en diverses bases de dades, amb criteris de selecció específics per a cada component i els seus suposats beneficis, amb preferència de les publicacions més recents. Els resultats mostren que alguns dels ingredients d'aquests suplementes sí que estan avalats per una sòlida evidència científica al darrere (com és el cas del cafè, el té verd i, en menor grau, l'Aloe Vera), però d'altres no compten amb una evidència prou significativa per atribuir-los els beneficis que asseguren (com succeeix amb els batuts substitutius, els suplementes vitamínics i d'omegues i el glucomanan); inclús s'han reportat efectes adversos relatius al consum d'aquests productes que, en alguns casos, han resultat en greus conseqüències per la salut. En conclusió, podem afirmar que el consum dels productes d'Herbalife® i Juice Plus+® no aporten beneficis en termes de salut i, per tant, cal adoptar mesures i polítiques eficaces que promoguin per davant de tot, els estils de vida saludable com a pilar bàsic de salut a la població.

Review

The price of “health”: Herbalife® and Juice Plus+® products under study

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Abstract: The popularity of dietary supplements is increasingly on the rise: people are turning to them both for the purpose of weight loss and to maintain good health, so that in recent months and with the influence of the Covid-19 lockdown, dietary supplement companies have multiplied their profits, with Herbalife® and Juice Plus+® among the biggest benefited, yet in both cases seems to be that the traders do not have the necessary knowledge on nutrition. The aim of this review is therefore to analyse the best-selling products of these companies in terms of their components and the available scientific evidence. The articles reviewed were obtained by a search through various databases, with specific selection criteria for each component and its supposed health benefits, giving preference to the most recent publications. Results show that some of these supplements' ingredients do have scientific evidence supporting them (as is the case of coffee, green tea and, to a lesser extent, Aloe Vera), but others lack of significant evidence to attribute their claimed benefits (as is the case of substitute shakes, vitamin and omega supplements and glucomannan); moreover, adverse effects related to the consumption of these products have been reported and, in some cases, these had led to serious health consequences. In conclusion, it can be stated that the consumption of Herbalife® and Juice Plus+® supplements do not provide benefits in terms of health, and effective measures and policies are needed to promote healthy lifestyles as the main important measure to adopt by the whole population.

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Key words: Herbalife; Juice Plus+; dietary supplements; hepatotoxicity; liver injury; Aloe Vera; green tea; caffeine; glucomannan; multivitamins

1. Introduction

Nowadays, we live in a world where nutrition is taking on an increasingly important role, therefore, in order to maintain and improve their health, people are becoming more and more concerned about their nutrition and eating habits [1], and are even willing to spend large amounts of money for the sake of their health. Along with this, worldwide obesity rates are on the rise [2], and some professionals even refer to it as the "obesity pandemic"; besides, aside the well-known harmful health consequences of obesity (cardiovascular disease, diabetes, apnoea, cancer, etc.) [1–5], being obese these days is frowned upon by society: people with overweight are frequently teased, which leads to psychological problems, including depression, low self-esteem, stress, anxiety or even eating disorders, among many others [6,7]; indeed, different

studies have concluded that obese people have a harder time while making friends, finding a job (and being paid the same salary as normal-weight people), not being discriminated by health professionals and many other daily activities [7–9]. For all these reasons, the vast majority of the population is afraid of obesity, and many overweight people would do anything in an attempt to get rid of some kilograms.

This is common knowledge among companies engaged in selling health-enhancing products and, actually, they see obesity as a marketing strategy to increase their profits. This is probably the reason why food or dietary supplements (DS) -which could be defined as “a product that is intended to supplement the diet, containing one or more dietary ingredients (including vitamins, minerals, herbs or other botanicals, amino acids, and other substances), that is intended to be taken by mouth as a pill, capsule, tablet, or liquid, and is identified on the front label of the product as being a dietary supplement” [10]- are currently present in a great number of households: the statistics reveal that, in 2018, 30% of the Spanish population consumed any type of DS [11], and these figures are even higher in the American population, where 52% of US adults also consumed some type of DS [12]; in other words, the use of DS continues to increase dramatically worldwide, mainly with the aim of losing weight but also because of the belief that it is necessary to supplement certain nutrients to ensure a healthy life, being the most popular calcium (9%), omega-3 (8%), magnesium-potassium (8%), vitamin D (8%) and multivitamins (8%) supplements [11].

It is true that at times it is necessary to supplement certain nutrients under medical prescription, especially when pathologies are involved, but a 2013 study [13] revealed that only 23% of these products were used according to the recommendation of a health professional, whereas the vast majority of people took these supplements on their own for the purpose of improving (45%) or maintaining (33%) their health. Thus, it is not all surprising that the enterprises selling these products have a growing turnover amounting to millions of euros or dollars per year (roughly \$30 billion/year [14]), in fact, it is projected that the global nutritional supplement industry will reach approximately \$300 billion by 2024 [15].

Typically, the sales business of most of these companies consists of hiring independent salespeople (who, in almost all cases, their prior knowledge of dietetics and nutrition is practically null and void) to promote and sell their products in exchange for a percentage of profit. Given the peak of new technologies and social networks, which allow instant connection with hundreds of people without much effort, it is reasonable that these forms of business are becoming more and more common. As a matter of fact, in Spain there are many companies that are currently engaged in this type of business through the sale of DS, Herbalife® and Juice Plus® being two of the most famous on social media and among the most benefited in recent times. Both focus on weight loss and maintaining a balanced diet, so among their products there are vitamin pills and supplements that claim to be fat burners, above all.

But, is it necessary to take DS as part of a healthy lifestyle? Indeed, are these products as effective and beneficial as they are claimed to be? To date, there is little scientific evidence to support the routine use of DS, let alone when the people taking them are not under the control of health professionals, but of shopkeepers whose knowledge of nutrition and dietetics is inadequate and insufficient to work with other people's health.

Taking all of this information into account, this review article aims to analyse some of the most famous products manufactured by these companies and, in particular, to highlight the scientific evidence-based certainty of the benefits of these products, or in other words, what does science say about their components and their claims.

2. Material and Methods

For the purpose of writing this bibliographic review article, a large search of studies and articles between 2010 and the present was carried out in Scopus, PubMed and Google Scholar

databases, using search terms likewise “herbal supplements”, “dietary supplements”, “weight loss AND supplements”, “weight loss OR hepatotoxicity AND supplements” and “herbal supplements AND hepatotoxicity”, unrestricted in terms of language, age or gender. With the aim of finding all available information about each specific component, a second search was made for the name of the component under study (plus “[MAJR]”) followed (with the command “AND”) by concepts such as “toxicity”, “evidence”, “adverse effects”, “weight loss AND effect”, among others; the publication date was not limited in this case, however priority was given to the most recent and up-to-date studies. A large-scale research has been conducted on general background information about the current general use of DS. In addition, some meta-analyses and reviews obtained above have also been particularly helpful in finding new bibliography and MESH terms.

For the evidence selection criteria, reviews, meta-analyses and randomised clinical trials were prioritised as the main source -given that these are the studies that show the strongest scientific evidence, although other types such as case-control studies have also been included- and were screened for relevance mainly on the basis of their abstracts.

Besides, some extra information related to specific food supplements has been obtained through the websites of selected governmental institutions, especially that of NIH (National Institutes of Health) [16], as well as the updated Dietary Guidelines for Americans (2020 – 2025) [1] has been used as a reference for the recommended daily intakes (RDI). Finally, in order to identify the ingredients of the different products analysed in this article and their nutritional claims, an intensive research has been carried out on the belonging websites of the respective companies (Herbalife® [17] and Juice Plus+® [18]).

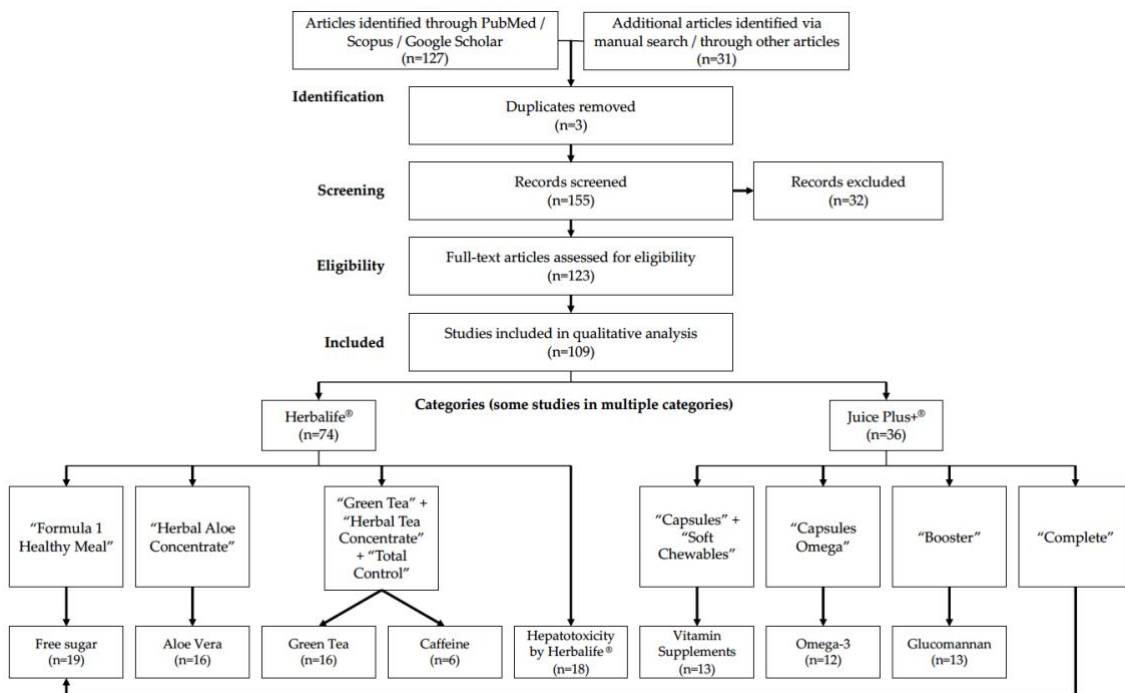


Figure 1. PRISMA flow diagram of search strategy.

3. Results

Both Herbalife® and Juice Plus+® are enterprises dedicated to the commercialisation of DS that claim to improve one’s health, but what exactly do their products actually contain? And how are these components actually involved in the alleged health improvement?

On the one side, Herbalife® has a wide range of products of all kinds, sorted into 4 categories: healthy weight, specialized in nutrition, energy & fitness and skin and hair care, which

are marketed in assorted formats, being the powder ones the most consumed [17]. On the other side, Juice Plus+® narrows down more on the nutritional side, offering nutritional supplements, mostly in capsules or chewable form [18].

Hence, the most consumed products of both brands will be analysed in-depth hereafter in terms of their health claims, while the scientific evidence regarding the most highlighted compounds these products contain will be reviewed.

3.1 Herbalife®

It is clear that Herbalife®'s best-selling products are those in the weight loss range, especially considering that the main reason why people attend Herbalife® is because of its promises of achieving their ideal weight and body figure with its products. In fact, Herbalife®'s profits for the first quarter of 2021 have already reached \$1.5 billion, representing an increase of 18.9% compared to the same period last year [19]; it is likely that this rise is a result of the fact that, during the Covid-19 pandemic lockdown, there has been a worldwide trend towards weight gain [20–23], and people are now looking for quick remedies to deal with this.

Some of Herbalife®'s top-selling products are analysed and reviewed below, along with the available scientific evidence regarding their compounds and health claims. Furthermore, the reported cases of hepatotoxicity (HT) caused by Herbalife® products will also be reviewed at the end of this sub-section. The general analysis is summarized in **Table 1**.

3.1.1. "Formula 1 Healthy Meal"

Herbalife®'s flagship product is its world-renowned "Formula 1 Healthy Meal", a ready-to-mix powdered shake that, when its blended with milk, is intended as a substitute for a meal or a snack. It belongs to the healthy weight category, and boasts to contain 21 vitamins and minerals, as well as providing an ideal balance of protein and other key nutrients [17]; furthermore, it is available in multiple flavours, the "Pralines and Cream" flavour being the one that will be taken as the reference sample to be studied. Examining its long list of ingredients, it can be ascertained that the second ingredient (and therefore a high fraction of the product content) is fructose [17], a rapidly assimilated type of sugar that, due to its small size, it enters straight into the enterocytes, leading to a rapid increase in blood glucose (hyperglycaemia) and, thereby, to a consequent hyperinsulinaemia [24–26]. That is, it generates a glucose and insulin peaks which, in turn, will lead to a drastic decrease in blood glucose (reactive hypoglycaemia) [25], which in the long term is directly associated with the development of type 2 diabetes [24,26–31]. It is therefore not surprising that the daily consumption of any type of free sugars (FS) is known to be associated with the development of pathologies and serious health problems (especially cardiovascular health) related to hypertriglyceridemia [27,28], non-alcoholic fatty liver [24,27,28,30,32], hypertension [24,28,30,33], reduced high-density lipoproteins [28] and cancer [24], among many others that can even lead to premature death [29]. On the other hand, sugar consumption has also been proven to harm dental health, as it damages tooth enamel and is the main cause of caries: these dental diseases are observed even when sugar intake is only 2–3% of energy intake [34,35]. For all these reasons, and taking into account that FS also contribute to the global energy density of diets [36], it is considered that the everyday and excessive consumption of FS (including fructose) contributes to overweight and metabolic syndrome [24,30], and even more so when these sugars are taken in the form of beverages, as they are absorbed much more quickly and are often consumed in greater volume [26,31,37]. In fact, the World Health Organization (WHO) recommends reducing the intake of FS to less than 5% (10% being the maximum) of total energy intake in both adults and children [36], which equates to an average amount of 25g of FS per day (on a 2000 kcal diet). The nutrition label of "Formula 1 Healthy Meal" states that 250 ml of this prepared product provides 20.9g of sugar [38], so if only one shake a day is consumed, there is a small margin of 4g of extra FS (if the 5% is desired, although it is recommended that the less amount consumed, the better), but Herbalife®

recommends taking two shakes a day in order to achieve weight loss [38], which represents a daily intake of almost 42g of FS through the consumption of this product alone, practically the double of the WHO's recommendations.

Nevertheless, it is true that the first ingredient is soy protein isolate (SPI) (and it is established that 0.8 g of protein/kg of body weight should be consumed in the general public [39]), which does have scientific evidence to support its beneficial effects on exercise-related muscle mass gain and physical endurance [40–42], even though some scientific literature suggests that regular consumption of SPI may also cause AE, especially those related to the presence of weakly oestrogenic compounds, such as reproductive toxicity, infertility, demasculinisation and increased incidence of oestrogen-related cancers (for instance breast cancer) [43].

In addition, its label states that “Clinical studies on U.S. Formula 1 (1 study) and on similar products show that Formula 1 shakes taken twice a day as part of a reduced-calorie diet help people lose weight”[44], but surprisingly it is not possible to access it to assess how it was carried out and whether there was or not a control group to check if the weight loss was truly a result of the combination of these two factors. Furthermore, for weight loss it is recommended to replace two meals per day with this product, but if the calories of this shake (170 kcal if consumed with 250 ml of non-fat milk [44]) are compared with the calories contained in a conventional meal (which in a healthy diet should provide between 450–650 kcal generically [1,45,46]), it is logical to observe a weight loss if more than 600 kcal are being missed per day. The problem arises when this diet cannot be sustained in the long term: firstly, because of its high economic cost (\$43.30 each pot [44]), and secondly, because good eating habits (nutritional education) are not inculcated, thus the consumer does not learn how to eat according to a healthy diet; moreover, even the Dietary Guidelines for Americans [1] advises not to replace the regular food intake with beverage supplements.

3.1.2 “Herbal Aloe Concentrate”

Another of Herbalife®'s most widely consumed products is its “Herbal Aloe Concentrate”, which belongs to the Specialized Nutrition category, within the Digestive Health sub-category. This supplement claims to be able to soothe the stomach, support healthy digestion, relieve occasional indigestion and support nutrient absorption and intestinal health [44]. However, there still remains high controversy surrounding the purported benefits of Aloe Vera (AV), therefore the following is a review of the scientific literature to date on AV and its benefits.

Aloe is a wide and succulent plant similar to a cactus, and it is cultivated in subtropical regions. There are over 420 different species of Aloe, Aloe Vera (*Aloe barbadensis* Miller) being the most widely known. The gel that its leaves contains has been historically used in the field of pharmacy for its medicinal properties, mainly on wounds and skin burns, and nowadays it is used in numerous commercial products [47,48]. AV can be both used topically and orally, and although the benefits from the topical use seem to be more clear -especially for acne and skin conditions- [49–51], there is still much controversy about its supposed benefits from oral use because of insufficient scientific evidence in humans [47]. The alleged benefits of AV are due to the active compounds it contains (polysaccharides (PS) -aloin-, vitamins, enzymes, minerals, anthraquinones, hormones, salicylic acid, amino acids, lignin, sterols, saponins and sugar) [52,53].

The positive effects of AV on the stomach and microbiota are due, mainly, to acemannan, a PS present in the leaves of this plant [54]. Most Aloe PS cannot be completely digested in the stomach and small intestine, so that they end up being hydrolysed by the microbiota. This does provide a benefit to human health, as the microbiota metabolizes these PS into, mainly, three short-chain fatty acids: acetic acid (which has a positive effect on immune and intestinal epithelial cells), propionic acid (considered to be a key factor in reducing fatty acid content in the liver and improving insulin sensitivity) and butyric acid (that can maintain the integrity of the intestinal barrier by regulating tight junction proteins and mucins) [55–57]. Liu *et al* [53] aimed to study the

effect of Aloe PS in mice's gut microbiota, and the results shown that the mice in the intervention group had significantly ($p < 0.01$) higher levels of these fatty acids (derived from the AV metabolism) compared to the control group, as well as it could also be demonstrated, by a heatmap, that the bacterial composition of the microbiota changed after being supplemented with the AV gel. The benefits related to these fatty acids were also observed. Additionally, while the mechanism has not been ascertained, a study proved its positive effects on digestion, where the intake of 10 ml/day of AV syrup has been shown to reduce gastroesophageal reflux symptoms [58]; and another study involving 43 adults with gastrointestinal symptoms (including indigestion) found that, after treatment with a supplement containing different herbs (including AV), these symptoms improved significantly by 40–60% [59]. Moreover, a review published in 2015 [60] summarized the biological activities of AV compounds (phenolic and saponin compounds, overall) and, among many others, describes its fibre-like effect, which helps in the delay of intestinal digestion and absorption. Nonetheless, it must be taken into consideration that depending on the part of AV used for the supplementation and the extract preparations, the results will be different. Yet, the studies available to date regarding the digestive effects of AV are still quite limited.

Regarding tolerance and safety, AV gel is usually well tolerated when used topically, although some cases of adverse skin reactions have been reported [47]; but when it comes to Aloe oral consumption, its tolerance and toxicity does not seem to be so clear. While there is some evidence of reported adverse effects (AE) from the consumption of AV -such as HT, liver dysfunction and hepatitis (considered the principal AE associated with herbal DS ingestion) [61–64], carcinogenic activity (observed in rats) [61–63], bleeding (probably caused by the reduction of the synthesis of prostaglandin induced by AV, which inhibits the aggregation of platelets) [61,62], renal failure [61,62], abdominal pain [61–63] or nausea [61,63], among others-, AV supplements are considered safe as long as aloin levels are below 50 ppm (parts per million) in any event, as suggested by The International Aloe Science Council standard [61]. In a new study undertaken in mice [65], the RDI of AV (2000 mg/day) was extrapolated to mice weight (33.3 mg/kg) in order to test for possible signs of toxicity, morbidity and mortality; results show that, after AV ingestion, there was no significant change in the number of bacterial colonies, as well as no significant difference in body weight, food intake and food utilisation rate in comparison with the control group ($p > 0.05$); in any case, it was concluded that AV did not produce any toxic effect up to 3330 mg/kg bodyweight. Nevertheless, further studies about AV safety are needed, especially since its consumption is becoming increasingly popular.

All the same, the "Herbal Aloe Concentrate" nutrition label states that the AV (purified juice of whole leaf) content is 40%, with sugar as the second ingredient (33%) [38], which health effects have been already discussed. However, if the AV content is actually less than half of the total product, the amount consumed is even less, as the instructions for use specify that 15 ml of the product must be mixed with 150 ml of water [38], which means that, in the end, only 6 ml of AV juice is consumed per intake.

3.1.3 "Green Tea", "Herbal Tea Concentrate" and "Total Control"

Herbalife® is also renowned for its popular teas: "Green Tea" and "Herbal Tea Concentrate". The first one belongs to the Energy & Fitness category and claims to provide hydration through the day, support the body's antioxidant activity, protect against free radical damage and contain no artificial colours, flavours or sweeteners and zero calories; the second one, instead, belongs to the Healthy Weight category as it claims to boost the metabolism (jump-starts thermogenic-metabolic- activity, boosts the feeling of energy, provides antioxidant support and is an instant and low-calorie product) [44]. The main difference between both is that "Herbal Tea Concentrate" contains caffeine and different types of tea among its ingredients (the second one being fructose, again), while "Green Tea" contains no active compound other than green tea

(it should be noted that it also contains caffeine, but the amount naturally contained in tea, so the total quantity is much less than in the previous case) [44].

Admittedly, there is scientific evidence behind the antioxidant and metabolism-boosting effects of green tea and caffeine -respectively-, which are reviewed in greater detail below.

Green tea extract (GTE) is made from the leaves of *Camellia sinensis*, and is classified into three categories: unfermented, semi-fermented and fermented. Given that GTE belongs to the first group (non-fermented), its production is achieved by inactivating the enzymes polyphenol oxidase and peroxidase, allowing it to maintain a large number of polyphenols (especially catechins, alkaloids and caffeine), which are the active compounds that confer GTE its health benefits, its most important one being its antioxidant potential capacity [66], as it has been proven in animal studies that GTE has the potential to increase the interleukin 2 and interferon gamma levels in the serum of chickens, as well as to enhance the production of anti-inflammatory cytokines in pigs [67,68]; besides, another study carried out on rats found that those that were treated with GTE presented, after the treatment, a higher activity of antioxidant enzymes: catalase ($p=0.002$), superoxide dismutase ($p=0.01$) and glutathione peroxidase ($p=0.01$) [69]. The accumulation of free radicals in the body is known to result in an oxidative state (also known as oxidative stress) that, among other things, causes lipid peroxidation, leading to a loss of Polyunsaturated Fatty Acids (PUFA), which have natural antioxidant effects [70,71], yet these active compounds and vitamins contained in GTE have been proven to reduce lipid peroxidation and the subsequent depletion of PUFA [72]; in turn, an in vitro study with human endothelial cells proposes that GTE inhibits angiotensin-converting enzyme, which decreases the amount of angiotensin II and therefore also oxidative stress (by decreasing blood pressure through the production of superoxide anion) [73]. However, it is important to emphasise that the bioavailability of GTE catechins is very poor, as most of them are cleared along the gastrointestinal tract before reaching the circulation [74]. Alternatively, in terms of providing hydration throughout the day, it stands to reason that if the GTE is infused in water, a hydrating effect is being produced, but not because of the tea itself, but because of the water. Nonetheless, some AE related to the uptake of GTE have been reported, the most common being severe liver injury (hepatotoxicity) -whilst the mechanism that causes it is unknown- [75–77], as well as drug interaction [78]; for that reason, a maximum daily dose of 300 mg/day is proposed for DS, although no hepatic effects have been observed in clinical trials involving twice this dose [79]. Until recently, it was believed that GTE consumption was also associated with the development of oesophageal cancer, but a recent meta-analysis has refuted this correlation as no statistical relationships were found in hardly any of the 14 studies they worked with [80]. Furthermore, Abualhasan *et al* [81] analysed eighteen random samples of green tea from Palestinian herbal medicine shops or community pharmacies and found that seven of them contained toxic metals in higher concentrations than those established by the WHO and, at the same time, six were also microbiologically contaminated. In short, although it is certain that GTE has great health benefits, it should not be over-consumed.

Caffeine is a xanthine alkaloid compound that is found not only in coffee (hence the name) but also in various plant components, including tea leaves, cocoa beans, guarana berries and kola nuts [82,83], and it is metabolised in theobromine, paraxanthine, and theophylline (its metabolites, which confer caffeine its beneficial effects) by the hepatic enzyme CYP1A2, which belongs to cytochrome P450 oxidase system, the main responsible for the oxidative metabolism of xenobiotics [84]; it is therefore true that caffeine, like green tea, provides an antioxidant effect on the organism. It is beyond dispute that caffeine stimulates the central nervous system, as its action mechanism consists of blocking the effects of the natural neuromodulator adenosine, leading to increased release of dopamine, noradrenalin, and glutamate [85,86], which provide the body with a greater feeling of energy. Moreover, there is scientific literature substantiating that caffeine and its metabolites are capable of inhibiting phosphodiesterases, which are responsible

for hydrolysing cAMP bonds, inhibiting their degradation, thus leading to an accumulation of cAMP, that may promote lipolysis in adipose tissue by triggering the activity of the hormone-sensitive lipase [83,86,87]. It can therefore be asserted that caffeine acts as a fat metabolism modulator. However, it is worth pointing out that these effects are observed when caffeine is consumed in large doses and, moreover, they have been studied with regard to physical exercise. Furthermore, like other psychoactive substances, caffeine could induce abuse and dependence [86], as well as can have adverse and toxic effects when consumed in excess (mainly sleep disturbance and anxiety in the short term, and cardiovascular problems in the long term), this is why the EFSA recommends not to exceed 400 mg of caffeine per day, with this recommendation being halved (200 mg) in the case of pregnant women [82].

Hence, both GTE and caffeine do have scientific evidence to support their health claims, yet the problem here stems from the high price of both products: 100g of "Herbal Tea Concentrate" costs \$46.20 (\$460.2/kg), and 48g of "Green Tea" costs \$38.50 (\$802.1/kg); therefore, it is far more expensive to buy these products than their substitutes in supermarkets, where it is possible to find coffee priced at €9.38/kg and green tea at €20.84/kg (taking the multinational supermarket group *Carrefour* as an example) [88].

Furthermore, Herbalife® also markets a DS called "Total Control", which is likewise made from tea, caffeine and extracts. As with the "Herbal Tea Concentrate", "Total Control" also comes under the category of Healthy Weight, since it claims to contain a "proprietary blend which helps to boost metabolism and support thermogenesis" [44], although it is also warned that these statements have not been evaluated by the Food and Drug Administration (FDA); but, yet again, its price is extremely high and many similar products are available on the market at considerably lower prices.

3.1.4 Reported hepatotoxicity related to Herbalife® products consumption

Given that Herbalife® was established in 1980 and therefore its customers have been purchasing its products for more than 40 years, it is normal that AE related to the use of its products have been reported, and even more considering that the company operates in more than 90 countries around the world, employing more than 10.000 people, hence millions of shakes and other products are sold every day globally [17]. Nevertheless, the situation starts to appear worrying when more and more cases of AE are being reported, and still more when severe pathologies such as cirrhosis, liver transplants and even death are involved. Additionally, as herbal supplements are recognised as safe and over-the-counter products, they lack adequate controls and are not investigated by the FDA [89,90], but it is important to point out that, while they may seem natural and harmless, nearly all herbal supplements have the potential to produce AE, especially when consumed without moderation [91], indeed, it is estimated that at least one in four patients with liver disease use herbal supplements [92]. As mentioned previously, most of the compounds highlighted in the analysis of Herbalife® products showed liver damage among their AE, so it is not surprising that the main AE relating to Herbalife® is HT (resulting from elevated hepatic transaminases [90]). The following are some of these cases of HT that have been documented over the years (all of which have ruled out alcohol, drugs and medication intake, as well as the existence of family history of liver disease).

In 2009, a case of a 63-year-old Argentinian woman with asthenia, jaundice and pruritus of 20 days' duration was reported; during the medical interrogation the patient stated to have been consuming Herbalife® products (including "Formula 1 Healthy Meal") twice a day for 10 weeks with the aim of losing weight, and the statistical examination concluded that the acute hepatitis she was diagnosed with was probably secondary to the ingestion of Herbalife® products [89]. A further publication in 2010 [93] reported two other cases of HT related to Herbalife® consumption in Los Angeles (USA): a 37-year-old woman with a diffuse abdominal pain, mild nausea, and painless jaundice that had been consuming Herbalife® products for the previous 3 months and whose initial blood tests were significant for an AST level of 2199 U/L, a serum ALT

level of 2068 U/L, a serum alkaline phosphatase of 185 U/L and a TB of 15.3 mg/dl; and a 53-year-old previously healthy woman with painless jaundice and pruritus who had been consuming various Herbalife® weight loss products for the previous 4 months, whose initial laboratory values revealed a pattern of hepatocellular injury, with an AST of 1282 U/L, ALT of 983 U/L, and alkaline phosphatase of 292 U/L, with a TB of 18.2 mg/dl and a borderline hepatomegaly of 17 cm discovered in a posterior ultrasound; both cases, once they left the hospital, improved their symptoms and recovered after abandoning the use of Herbalife® products completely. Another more recent case has been reported [94]: a 54-year-old Croatian female patient, previously healthy, was hospitalised for abdominal pain, pale stools, tiredness and general weakness and, there again, initial laboratory tests showed significantly elevated markers of hepatocellular damage; it was found later that the patient had been taking a multitude of Herbalife® products (without exceeding the recommended doses) for at least half a year. Similarity, much more cases with very similar characteristics have been reported in numerous publications (especially during the first decade of this century), some of them even required a liver transplant, while a minority could not overcome this liver failure and died [64,95–100]; indeed, at least 50 cases of liver damage in Herbalife® users have been reported to date [101], of which 32 occurred in Spain alone (among them one liver transplant and one death were reported) [102], yet curiously, virtually no cases have been described in Spain in the last 10 years [77].

Additionally, a large number of reviews and meta-analyses of Herbalife® consumption in multiple countries (Switzerland, Israel, Spain, Argentina, Iceland, US and Italy, among many others) and the subsequent diagnosis of HT state that this correlation appears to be significant in most cases [92,103–105], even if the HT attributed to Herbalife® products remains unexplained, especially since Herbalife® has a wide range of products with very different ingredients, making it difficult to find a mechanism of action [101], although some cases of HT have been attributed to the consumption of Herbalife® products contaminated with *Bacillus subtilis* [99] and, as described previously, the excessive consumption of sugar derived from their products is likely to play a role in this liver damage.

Finally, it is important to note that it is very likely that there are much more cases of HT due to Herbalife®, as patients generally do not perceive these products as harmful (in fact, they consume them with the aim of improving their health) and therefore do not always report the intake of DS in the medical interview [104].

3.2. Juice Plus+®

Juice Plus+®' ethos, in turn, revolves more around supplementing some nutrients to the diet through the sale of its products, rather than selling pills aimed specifically at weight loss, even though there are some products for that purpose as well. In other words, the Juice Plus+® method consists of following a healthy diet, doing sport on a regular basis and taking its food supplements; as a result of these 3 factors, the company promises improvements in overall health [18]. The company has grown in popularity in the last year, largely as a result of the Covid-19 pandemic, which has made people increasingly concerned about their health [106].

Some of the most popular products from JuicePlus+® are detailed below and analysed in terms of their claims and the existing evidence on them. **Table 2** summarized a general analysis.

3.2.1 "Capsules": fruit, vegetable and berry

The basis of the JuicePlus+® method lies in its famous assortment of 3 different capsules, which boast of containing 30 different varieties of selected, high quality fruits, vegetables and berries. The recommendations are to take 2 capsules of each variety per day (at lunch and dinner, preferably) in order to obtain the vitamins that these tablets provide thanks to the industrial process to which these foods have been subjected, which allows them to maintain their beneficial compounds. This three-pack of DS is rich in, above all, vitamins A, C and E; in fact, by consuming the recommended 6 capsules (3 of each) a day, one is already ingesting a total of 490 µg of vitamin

A, 156 mg of vitamin C and 26 mg of vitamin E (apart from vitamins naturally occurring in the diet), whereas the RDI is, respectively, 700 µg (females) / 900 µg (males), 75 mg (females) / 90 mg (males) and 15 mg [1], which represents 61% of the RDI of vitamin A, 197% of vitamin C and 217% of vitamin E [1,18]. Besides, the first ingredient is (in all cases) a powder blend of the juice and pulp of the different vegetables, fruits and berries [18] which, since they are removed from the food matrix (FM) and thus have lost the fibre that surrounds them, they become rapidly absorbed sugars, which have the potential to induce adverse nutritional effects (as described previously) [107].

There is no doubt that these supplements are of extremely high quality, but the current scientific evidence calls into question the necessity of taking vitamin supplements in the context of a healthy diet, and even more so when the RDIs are doubled.

A recent review [106] examined almost 90 studies to determine whether vitamin supplementation (VS) is really necessary, and concluded that while previous studies (from the 1990s and earlier) pointed to improvements in health and lower risk of mortality from VS, contemporary scientific research differs from the earlier studies, as no evidence has been found to justify VS in the general public. This difference is primarily due to the fact that the first studies were not randomised clinical trials (mostly were observational studies), whereas the latest ones are and thus have greater scientific validity. In addition, it is known that people who regularly take vitamin supplements also commonly tend to follow a healthy diet -such as the Mediterranean- which may have been a possible confounding factor in the earlier studies. This review also emphasises the importance of considering whether subjects are already reaching the RDI of vitamins through their diet or if VS allows these levels to be reached and therefore positive consequences are observed. Accordingly, the authors came to the overall conclusion that there is no scientific evidence suggesting a correlation between VS and health improvement in the general public. Other up-to-date articles [108–110] came to a broadly similar conclusion: supplementation with DS is generally not necessary, as the micronutrient requirements of a healthy person can be adequately met by a balanced diet and, moreover, when the organism already has the necessary amount of vitamins, surplus vitamins are either excreted in the urine (in the case of hydro-soluble vitamins such as vitamin C) or stored (in the case of fat-soluble vitamins such as vitamin A and E), leading to possible toxic effects.

Nevertheless, it is true that in some pathologies or specific situations beneficial effects after VS have been observed [106], for instance, VS is necessary in oncology patients with vitamin deficiencies (since in this disease an adequate supply of vitamins C and D must be ensured) [108]; but in any case, it must be a doctor or a health professional who prescribes these supplements, evaluating and monitoring each individual case.

Furthermore, the issue is not only that VS is not necessary in the general population and do not result in beneficial health effects, but also that over-consumption of vitamins can be toxic and harmful to health, especially when it comes to fat-soluble vitamins [43,107]. Vitamin A and its carotenoid precursors are one of the most potentially toxic vitamins when consumed in excess, in fact, vitamin A supplementation (in the form of β -carotene) in smokers has been clinically shown to increase lung cancer risk, and an excessive vitamin A supplementation has been implicated in AE upon bone health (including low bone mineral density and increased risk of fracture), as well as an increased incidence of congenital anomalies in women who consumed vitamin A in excess during pregnancy, among many other pathologies and AE associated with excessive vitamin A supplementation [43]. Vitamin E constitutes a family of 8 tocopherols and tocotrienols, with α -tocopherol being the most commonly used form in supplements [43]; it acts as an antioxidant in human body, so its consumption should not be underestimated, however, it has been studied that doses of 800-1200 mg/day of vitamin E had affected both platelet aggregation and platelet adhesion (which often results in haemorrhages) in patients with abnormal platelets (e.g. diabetics), and even higher intakes have been correlated with diarrhoea,

weakness, blurred vision and gonadal dysfunction [43,111]; moreover, vitamin E inhibits collagen synthesis and therefore its excessive intake can negatively affect wound healing [111]. Vitamin C -another potent antioxidant- also reports toxic effects related to its excessive consumption, such as cytotoxicity in cancer patients [112] and damage to the gastrointestinal tract (at doses between 40 mg/d and 1000 mg/d) [109]. Moreover, there have been observed significant associations (RR 1.04; 95% CI: 1.01, 1.07) with health harm in systematic reviews where participants were treated with placebo or anti-oxidant supplements (Vitamin A, C, E, β -carotene and selenium) [109]. Attention should be drawn to the fact that it is all but impossible to achieve such high amounts of vitamins from diet alone, whereas VS makes it much easier.

In addition, it should be noted that the behaviour and bioavailability of several nutrients differs when they are naturally present in their FM from when they are consumed in isolation in the form of a supplement, due to the multiple interactions between nutrients, the FM and other food components present in a meal [107,113–116]; as a matter of fact, experts are now proposing to consider the food as a whole, rather than focusing on specific nutrients, given that the combination of food ingredients and their structure may change its physiological effects [117]. This is presumably the reason why one of the most important premises of the Dietary Guidelines for Americans [1] is that nutritional needs should be met primarily with naturally rich-nutrient foods and beverages, using fortified foods and DS only on those occasions when they are strictly necessary.

3.2.2 “Soft Chewables”: fruit, vegetable and berry

Alongside the capsules, Juice Plus+® also markets supplements that are more akin to candy, but which, after all, have the same purpose as the capsules described above: to supplement vitamins A, C and E. They also come in the same 3 different varieties: fruit, vegetable and berry. The main difference is that these are targeted more at children (although they can also be consumed by adults) and, therefore, the first ingredients in these are sugar in different forms [18] (the detrimental health effects of which have already been described).

3.2.3 “Capsules Omega”

It is a well-known fact for Juice Plus+® that nowadays the vast majority of the population does not achieve the RDI of Omega-3 fatty acids (1.1 g/day in females and 1.6 g/day in males [1]), especially in America and Europe, where a western eating pattern, far removed from a healthy diet, is increasingly being adopted [118–120]. The health authorities warn of the importance of consuming the necessary amounts of omegas in order to avoid deficiencies, which can lead to health problems such as rough, scaly skin and dermatitis [121], and even to cardiovascular disease, diabetes, cancer, obesity or autoimmune diseases, among many others [122,123], given that Omega-3 main role in the body is to be a component of the phospholipids in cell membranes, acting against inflammation [124]. Therefore, it is understandable that another of Juice Plus+® top products are its omega blend capsules, a food supplement that provides 825 mg of omegas (375 mg of Omega-3: 175 mg of DHA, 100 mg of EPA and 35 mg of ALA) in two capsules [18]. But then again, this is the same issue as with multivitamin supplements: controversy exists as to the need for omega supplementation in the context of a healthy diet.

Omega-3 is one of the most important types of PUFAs which, together with Omega-6, is essential and must therefore be consumed through the diet (as our body is unable to synthesise the carbon-carbon double bond located three carbons away from the methyl end of the chain that it has). There exists another division according to the number of carbons in the fatty acid, with alpha-linolenic acid (ALA, 18 carbons), eicosapentaenoic acid (EPA, 20 carbons) and docosahexaenoic acid (DHA, 22 carbons) being the most important ones. These are mainly obtained from fish, vegetable oils and seeds and other plant sources like walnuts, soybeans, cauliflower or brussel sprouts [124,125].

On the one hand, it is true that great benefits have been obtained after omega-3 supplementation in certain pathologies or concrete occasions, such as in critical Covid-19 patients (due to the improved levels of various parameters of respiratory and renal function) [126], in mild Alzheimer's disease (because of the possible affectation of brain function) [127], in patients with chronic kidney disease (by the improvement of cardiometabolic parameters) [128] or in post-menopausal women [129], among many others; as well as Omega-3 supplementation has led to improvements in overall health when combined with aerobic physical exercise [130].

On the other hand, no significant improvements in health have been observed when these PUFA have been supplemented in healthy people; however, the little evidence available has been conducted exclusively in children and adolescents, hence further research is needed before a stronger conclusion can be drawn [131]. Still, it should be borne in mind that the consumption of, as an example, 100 g of salmon already provides 1966 mg of Omega-3 [125], which is more than enough to meet the RDI. Indeed, the Dietary Guidelines for Americans recommends at least two servings of seafood per week with the goal of reducing the risk of these aforementioned omega-3 deficiency-related health problems [1].

Finally, it has been suggested that Omega-3 fatty acid supplements are likely to aggravate anticoagulation and promote bleeding in patients prescribed anticoagulant medications such as warfarin [43], although its supplementation does not generally have toxic effects.

3.2.4 “Booster”

Another of Juice Plus+®'s most widely consumed products is its food supplement called “Booster”, which contains glucomannan (33%), GTE (3.3%) and caffeine (along with oils and fructose). This supplement is famous among consumers because it claims to assist weight loss (as part of a low-calorie diet) thanks to glucomannan [18]. It is true that glucomannan has always had a reputation for weight loss, but the scientific evidence available today calls this supposed effect into question; its current research is discussed in greater detail below.

Glucomannan (a hydrocolloid PS) is a soluble dietary fiber naturally present in many products, the most famous being cognac (*Amorphophallus konjac*), since it is usually obtained from its roots [132,133]. One of its main characteristics is its high water absorption capacity: up to 50 times its weight, which allows it to form a gel-like mass in the stomach [132]. Due to this fact, it is believed that glucomannan, which is fermented in the colon by the gut microbiota [134], could increase the feelings of satiety and fullness and also prolong gastric emptying [135], as well as it might also decrease the absorption of fat and protein in the gut [132]. However, the mechanism by which glucomannan would induce weight loss is not yet known exactly.

Studies have shown that glucomannan seems to have beneficial effects on plasma lipids and glucose levels, in both animals and humans [135,136], and the European Food Safety Authority (EFSA) concluded in 2010 that glucomannan contributes to the reduction of post-prandial glycaemic responses, maintenance of normal blood glucose concentrations, maintenance of normal (fasting) blood concentrations of triglycerides, maintenance of normal blood cholesterol concentrations, maintenance of normal bowel function, decreasing potentially pathogenic gastro-intestinal microorganisms and reduction of body weight in the context of an energy-restricted diet in adults who are overweight [137], but nowadays there is a lot of controversy regarding this last point.

It is true that a study carried out in the USA in 1983 with obese women showed that the intake of 3g of glucomannan per day (divided in 3 equal doses: one before each meal) produced a significantly greater weight loss ($p \leq 0.005$) compared with the placebo group, but the number of participants (20 voluntaries) was too small to obtain meaningful conclusions [138]. Many other studies dispute its supposed slimming effect: Keithley *et al* analysed the effect of 8 week glucomannan supplementation before each meal in 53 overweight adults who did not change neither their dietary pattern nor activity habits, and concluded that there was no significant weight loss between intervention and placebo groups [139]; another more recent study conducted

with children and adolescents with a similar methodology obtained the same results: a nonsignificant difference in weight loss between glucomannan and placebo [140].

Lastly, some systematic reviews of different randomized controlled trials have concluded that the current evidence on the weight-reducing power of glucomannan is limited, and that in any case it could help to reduce body weight but not BMI (Body Mass Index) in the short-term; however, in general, the glucomannan supplementation does not generate significant weight loss [141,142]. The same conclusion was reached by a 2014 meta-analysis that included 301 participants in eight different trials [143]. Besides, there is little evidence of the glucomannan effects on children, which makes it impossible to draw a firm conclusion [87].

Regarding tolerance and safety, glucomannan is commonly well tolerated with little or no gastrointestinal side effects, except when ingested in tablet form, which has been associated with seven cases of oesophageal obstruction, but this commercial form is no longer available [135,139]. However, it should be emphasized that almost all the information obtained to date is for short-term glucomannan supplementation, so it is not applicable in the long term (in most of the studies that analysed the glucomannan supplementation effects in long term, the treatment was combined with other supplements, such as *Garcinia cambogia* [144]).

3.2.5 “Complete”

Following the example of Herbalife®, Juice Plus+® also offers a product that purports to be a meal replacement named “Complete”, which is available in two flavours: vanilla and chocolate. The ingredients and method of use are very similar to the Herbalife® “Formula 1” shake explained above so, therefore, it will have the same effects.

Table 1. Herbalife®’s products: main components, current evidence about their claims, level of evidence, mechanism of action and possible adverse effects.

Product	Main component	Quantity	IDR	Claim	Quality of evidence	Mechanism of action	Adverse effects
“Formula 1 Healthy Meal”	soy protein isolate	17.4 g/serving	0.8 g/kg/d	to maintain a healthy weight and/or to lose weight	medium (in the short term)	replacing a meal with a “Formula 1” shake represents a significant daily kcal loss, which leads to weight loss, but excessive consumption of free sugars is a health hazard	reproductive toxicity, infertility, demasculinisation, increased incidence of estrogen-related cancers
	fructose	approx. 20 g/serving (250 ml)	max. 25 g/d				hypertriglyceridemia, non-alcoholic fatty liver, hypertension, reduced high-density lipoproteins, cancer, harm dental health, diabetes, metabolic syndrome, etc.
“Herbal Aloe Concentrate”	Aloe Vera	40 ml/100 ml (6 ml/serving)	max. 2 g/d	to soothe the stomach, support healthy digestion, relieve occasional indigestion and support nutrient absorption and intestinal health	low - medium	specific mechanism of action is not assessed, however, PS present in Aloe Vera are not completely digested, so they are hydrolysed by the microbiota in short-chain fatty acids, which provides a benefit to human health; also, it has a fibre-like effect, helping to delay digestion and intestinal absorption	hepatotoxicity, liver dysfunction and hepatitis, carcinogenic activity, bleeding, renal failure, abdominal pain, nausea, etc.

Product	Main component	Quantity	IDR	Claim	Quality of evidence	Mechanism of action	Adverse effects
"Green Tea"	green tea	not established					
"Herbal Tea Concentrate"	green tea	not established	max. 300 mg/d (for dietary suppl.)	to provide hydration through the day, support the body's antioxidant activity, protect against free radical damage	medium-high	polyphenols of green tea increase the interleukin 2 and interferon gamma levels, enhance the production of anti-inflammatory cytokines, boost the activity of antioxidant enzymes, reduce lipid peroxidation (depletion of PUFA) and inhibit angiotensin-converting enzyme (decrease oxidative stress)	severe liver injury, drug interaction, intoxication due to microbiological contamination and the presence of toxic metals
	caffeine	approx. 85 mg/serving (1.7g)					
"Total Control"	caffeine	82 mg/serving (1 tablet)	max. 400 mg/d	to jump-start thermogenic - metabolic- activity, boost the feeling of energy and provide antioxidant support	medium-high	stimulates the central nervous system (by blocking the effects of the natural neuromodulator adenosine), which provides the body with a greater feeling of energy; inhibits phosphodiesterases, which promotes lipolysis by triggering the activity of the hormone-sensitive	induces abuse and dependence, sleep disturbance, anxiety, cardiovascular problems, etc.
	green tea	not established	(below)		(below)	(below)	(below)

Table 2. Juice Plus+®'s products: main components, current evidence about their claims, level of evidence, mechanism of action and possible adverse effects

Product	Main component	Quantity	IDR	Claim	Quality of evidence	Mechanism of action	Adverse effects
“Capsules” (fruit, vegetables and berries)	Vitamin A, C and E	490 µg Vit. A + 156 mg Vit. C + 26 mg Vit. E / 6 capsules (2 of each)	700 mg (females) / 900 mg (males), 75 mg (females) / 90 mg (males) and 15 mg	to supplement the diet with vitamins in order to avoid vitamin deficiency	very low (high in specific groups)	if vitamin levels in the organism are the appropriate ones, surplus vitamins are excreted by urine or stored	increased lung cancer risk in smokers, low bone mineral density, increased risk of fracture, increased incidence of congenital anomalies in pregnant women, haemorrhages in patients with abnormal plaquettes, diarrhoea, weakness, blurred vision, gonadal dysfunction, worse wound healing, cytotoxicity in cancer patients, gastrointestinal tract damage, etc.
“Soft Chewables” (fruit, vegetables and berries)	Vitamin A, C and E	234 µg Vit. A + 78.5 mg Vit. C + 11.5 mg Vit. E / 6 capsules (2 of each)					
“Capsules Omega”	Omega-3	375 mg	1.1 g/day (females) 1.6 g/day (males)	to supplement the diet with essential omegas in order to avoid its deficiency	low (high in specific groups)	further studies are needed to conclude whether or not Omega-3 supplementation would have a positive effect in the context of a healthy diet (which already allows the RDI to be achieved)	aggravated anticoagulation and promotion of bleeding in patients prescribed anticoagulant medications

“Booster”	glucomannan	33 g/100g	not established	to assist weight loss	very low	specific mechanism of action is unknown, however, it may increase the feelings of satiety and fullness and prolong gastric emptying by its high water absorption capacity	gastrointestinal problems and oesophageal obstruction (only in tablet form)
“Complete”	fructose	(below)	(below)	(below)	(below)	(below)	(below)

4. Discussion

Due to the significant worldwide increase in the consumption of dietary supplements (DS) (mostly with the aim of losing weight or improving overall health) and the subsequent importance that the companies selling them are taking on the market -especially the firms Herbalife® and Juice Plus+®, along with the little awareness that exists among the general population about them, it is important to review which are the components that these products include and what does evidence state about them, in order to demonstrate if they are really useful (and safe) or, by the opposite, they are nothing but a scam that seeks to take advantage of people's desperation and insecurities about their physical condition and do business with it. Accordingly, the aim of this review was to analyse the leading products of both companies and to review the current scientific evidence regarding their components, as well as to assess how reliable their claims are.

Firstly, it should be noted that the vast majority of the DS sold are not under the prescription of a health professional. The business method of these two companies consists of employing people to trade their products in exchange for a percentage of the profits, being themselves responsible for training their employees in the field of nutrition, but unfortunately, these traders generally have neither sufficient knowledge nor official certification to intervene in other people's health. Secondly, the potential adverse effects (AE) of these components have been analysed throughout this review, in particular when they are ingested inordinately, and it has been proven that practically all of them can cause AE, some more serious than others.

On the one hand, the Herbalife® products analysed were: "Formula 1 Healthy Meal", "Herbal Aloe Concentrate", "Green Tea", "Herbal Tea Concentrate" and "Total Control". The first one, which claims to promote weight loss, has turned out to be a meal replacement that contains less than 200 kcal, while a regular meal has around 500 kcal, hence it is logical that in the short term weight loss is observed if so many kilocalories are deprived daily, but this is far from being a healthy and balanced diet; moreover, the second ingredient present in these shakes is fructose, a rapidly absorbed sugar that, as mentioned in the results, when consumed on a daily basis (and with just one shake, the WHO's daily total free sugar limitations are already reached) is likely to result in serious health problems and, ironically, obesity. The second is Aloe Vera juice to be diluted which claims to incorporate the digestive benefits of this plant, however, although there exists evidence in this regard, it is quite limited and studied with so small populations to be strongly significant, this is why it needs to be investigated further; in addition, it is excessively overpriced (\$33.05 for 473 ml) and there have been many reports of AE related to its consumption, both in excess and in normal doses. Finally, its line of teas (generally containing green tea and caffeine) claims to provide the benefits that these compounds naturally possess: antioxidant activity and activation of the metabolism; it is true that there is considerable evidence in this respect, but the problem is the same as in the previous case: they are extremely expensive, and there are products on the market with the same characteristics at much more affordable prices; moreover, in order to achieve truly significant effects, they must be consumed in large doses, which can lead to AE, and it must also be noted that the amount of green tea in these products is not specified. Not only is the sales methodology the problem, but since the beginning of the century, serious cases of hepatotoxicity (HT) have been reported with the only commonality being the consumption of Herbalife® products, requiring numerous liver transplants and, regrettably, a series of deaths. Although the exact mechanism inducing HT has not been demonstrated, these correlations appear to be significant.

On the other hand, Juice Plus+® products are more targeted at supplementing nutrients to the diet (although its methodology already includes a healthy and balanced diet combined with sport), which is why its best-selling products include fruit, vegetable and berry capsules and soft chewable forms, a series of supplements containing high amounts of vitamins A, C and E;

actually, with the consumption of 6 tablets a day (as recommended by the company), RDIs are already being doubled. Omega supplements, which are intended to prevent Omega-3 deficiency in particular, are also widely sold, as it has been proven that a large proportion of the population does not meet the daily recommendations. As commented previously, there is no scientific evidence to date supporting the supplementation of these nutrients in the general population, as in a balanced diet the RDI are already being met; indeed, when the body has already reached the necessary vitamin levels, the remaining vitamins are expelled, and it is likely to lead to a vitamin excess that is toxic in many cases, especially when it comes to the liposoluble ones. Juice Plus® also trades a product named “Booster” which claims to assist weight loss as it contains glucomannan, but the current evidence has not found significant changes in weight loss due to its component. Finally, another of its top products is its “Complete” shake, which is very similar in ingredients to Herbalife®’s “Formula 1” and has the same purpose.

Hence, it can be asserted that the regular consumption of Herbalife® and Juice Plus® products, in the context of a healthy lifestyle (as the companies themselves defend), is unnecessary -given that they have been shown to provide no significant health benefits- and even unsafe. It is true that nowadays a very unbalanced eating pattern is increasingly being adopted, which leads to deficiencies of many nutrients and, consequently, progressive loss of health. Notwithstanding, the solution does not lie in spending a lot of money on DS like these as if they were magic pills, but in developing useful and effective policies and advertisements that help and promote population to lead a healthier lifestyle, as well as incorporating nutritionists in public health in order to prevent people from falling for these scams and putting their health in the hands of unfit people for it. However, it is true that in some particular cases (such as pregnant women, states of malnutrition or specific pathologies, among others) the nutrient supplementation is necessary and even compulsory; but in any case, this has to be guided by a health professional with the necessary skills to monitor each case properly and take into account all the characteristics of the patient.

In summary, the market for DS should be more controlled and reviewed by professionals, especially taking into account that its consumption is on the rise and this is leading to serious health consequences in some cases. Further research is needed concerning the effects of DS on the general public and their efficacy or uselessness in a healthy diet, as well as on the mechanisms leading to the benefits and toxic effects of these components which remain to be assessed; only in this way a clear conclusion can be drawn.

5. Conclusion

In conclusion, this review proves that the use of dietary supplements (particularly those commercialised by Herbalife® and Juice Plus®) is unnecessary in the context of a healthy diet and, ironically, could lead to serious health consequences. Moreover, it is recommended that nutrients should be obtained from the food itself and not from supplements.

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List of abbreviations

AE	Adverse effect(s)
AV	Aloe Vera
DS	Dietary Supplement(s)
FM	Food Matrix
FS	Free sugar(s)
GTE	Green tea extract
PS	Polysaccharide(s)

PUFA Polyunsaturated Fatty Acids
RDI Recommended Daily Intake(s)
SPI Soy Protein Isolate
VS Vitamin Supplementation
WHO World Health Organization

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