Nutrafoods (2022) 1:370-378 DOI 10.17470/NF-022-0046

Original Research

Commercial antioxidant health products in Singapore: compositions and claims

Abstract

Oxidative stress has been implicated in the pathogenesis of numerous chronic diseases, such as diabetes and cardiovascular disease. Increased antioxidant intake may help alleviate oxidative stress and delay disease progression. This study evaluated the demography, antioxidant compositions, health claims, and non-health related claims of antioxidant health products commercially available in Singapore. The required data of the selected products were extracted from the product labels. The 74 selected products were chosen equally from physical stores and e-commerce platforms, and originated from Asia, Australia/New Zealand, and the United States. They were predominantly delivered in swallowable forms and cost S$2.07±1.84 daily. Most of the products (79.4%) specified the antioxidants on their labelling but only 29.8% stated their compositions. Vitamins (vitamins C, E, and A) and minerals (zinc and selenium) were the more prevalent antioxidants. Other antioxidants included carotenoids and flavonoids/phenolics/polyphenols. All the surveyed products stated health claims on their labels. Antioxidant, immunity, skin health, cardiovascular health, and gut health made up the top health claims. The absence of gluten and wheat, artificial flavouring, dairy, preservatives, and artificial colourings were the most common non-health related claims. When information about the composition of the antioxidants on the label is incomplete, the credibility of the product and its health claims is severely discounted. Titanium dioxide was the most popular colourant. This is concerning as a recent review by the European Food Safety Authority concluded that titanium dioxide can no longer be considered safe as a food additive. The choice of colourings should be reconsidered to prioritize consumer safety.

Keywords: Antioxidants, health products, health claims, non-health claims, additives

Rachael Tan [1]

Wai Mun Loke* [1, 2]

[1] School of Applied Sciences, Nanyang Polytechnic, 180 Ang Mo Kio Ave 8 Singapore

[2] Innovprof Singapore, 27 Orange Grove Road #05-02 Singapore 258356

*Corresponding author:
Wai Mun Loke

wai.mun.loke@innovprof.com
27 Orange Grove Road #05-02
Singapore 258356

Introduction

Reactive oxygen species (ROS) are produced as by-products of metabolism, regular respiration, the autoxidation of xenobiotics, or as the result of stress that accompanies a range of diseases [1]. Living organisms are constantly exposed to ROS and these ROS can react with biomolecules including lipids, carbohydrates, nucleic acids, and proteins, causing oxidative damage [1]. Oxidative stress arises when there is an imbalance between ROS and antioxidant defences in favour of ROS. It has been implicated in the pathogenesis of numerous diseases, including atherosclerosis, diabetes, and stroke [2, 3]. A complex mechanism of natural enzymatic and non-enzymatic antioxidant defences operates in the human body to counteract the harmful effects of oxidative stress [4]. This mechanism may help slow down or delay the progression and prevent or reduce the incidence of disease. When the innate, natural antioxidant defence is overwhelmed by excess ROS, it becomes essential to restore the oxidative balance by increasing the intake of exogenous antioxidants [4].

An antioxidant is defined as a substance that directly scavenges or inhibits ROS production, or indirectly acts to up-regulate antioxidant defences [4]. ß-Carotenes, vitamin C, vitamin E and l3-carotene are potent, direct, vitamin antioxidants [5]. Minerals – as critical components of antioxidant enzymes – act as indirect antioxidants: copper, manganese, and zinc are essential for the activity of superoxide dismutases [5]; iron is required for catalase activity and selenium is required for glutathione peroxidase activity [5].

Antioxidant health products are commercially available in many countries. A health claim is a message or representation made on a product relating to a product's indications, benefits or action [6]. The claim may be stated directly or inferred through, but not limited to, the product or brand name, graphics or logo on its packaging, media advertisements, point-of-sales materials, and product brochures [6]. Under regulations in Singapore, health claims can be classified as general claims that support or maintain health and well-being, or specific claims that enhance specific body functions or structures [6]. Antioxidant health products must not be labelled or promoted for medicinal purpose or carry implied claims for the treatment or prevention of diseases and disorders [6]. A non-health related claim serves to communicate to the consumer a unique product feature that is not associated with health benefits. Currently, there is limited data on the antioxidant compositions and dosages of the antioxidant health products commercially available in Singapore. Data on the health and non-health claims of these products are also scarce.

This study aimed to examine the health and non-health related claims made by the antioxidant health products that are commercially available in Singapore. Their antioxidant compositions and dosages, demography (country of manufacture, indications, claims, delivery form, and daily consumption cost) and additive compositions, such as colourings, flavourings, preservatives, and sweeteners, of these products were also examined.

Materials and Methods

Data collection

All health products on the shelves of three major pharmaceutical retail outlets (Guardians, Watson, and Unity) and two major e-commerce platforms (Lazada and Shopee) in Singapore claiming to be antioxidants were included in this study. The demographic information, such as country of manufacture, claims, delivery form, price, antioxidant composition, health and non-health related claims made by these products were recorded by trained research

personnel. This information should be printed on the item's packaging as regulated by the Health Science Authority, Singapore. The presence of added colourings, flavourings, preservatives and sweeteners in each item was also noted from its product label. The daily cost was computed by dividing the product's price by the number of daily doses, which was calculated as the ratio of the delivery units in the product to the number of delivery units recommended to be taken daily.

Data analyses

Data were statistically described and analyzed using Microsoft Excel (version 2103, April 2021).

Results

Product demography

Seventy-four products were included in the study. The products were evenly sourced from physical stores (59.5%) and e-commerce platforms (40.5%). They were manufactured in three distinct geographical regions: Asia (36.5%), Australia/ New Zealand (27.0%), and the United States (36.5%). These products were mostly delivered in capsule form (43.2%). Other popular delivery forms included liquid (13.5%), powder (13.5%), soft gels (13.5%), and tablet (12.2%). Gummies and jellies made up the remainder. The cost of daily consumption, based on the recommended doses, was computed to be S$2.07±1.84 (mean±SD), ranging from $0.14 to $10.80. Nearly all the products (94.5%) cost less than $5.00 per day, with most (69.9%) requiring less than $2.00 daily.

Antioxidants

Of the seventy-four products, 79.4% specified the antioxidants contained in the product. Vitamin C, vitamin E, vitamin A, zinc, and selenium were the top five antioxidants present in the surveyed products (**Fig. 1**). After stratifying into classes, the antioxidants included carotenoids (5.4%), flavonoids/phenolics/polyphenols (21.6%), minerals (25.7%), vitamins (70.3%), and others (29.7%). Vitamins – vitamins A, C, D, E, and K – composed the most popular class of antioxidants, with vitamin C the most prevalent vitamin antioxidant (**Fig. 1**). The minerals selenium and zinc made up the second most popular antioxidant class (**Fig. 1**). The added phytochemicals included unspecified flavonoids, hesperidin, resveratrol, rutin, and soy isoflavones (**Fig. 1**). Coenzyme Q10, ginseng, L-glutathione, and turmeric root made up the other antioxidant compounds in these products (**Fig. 1**). Among the products that stated the antioxidant compounds, 29.8% declared the amounts. The amounts of antioxidant compounds (mg) are presented in **Table 1**.

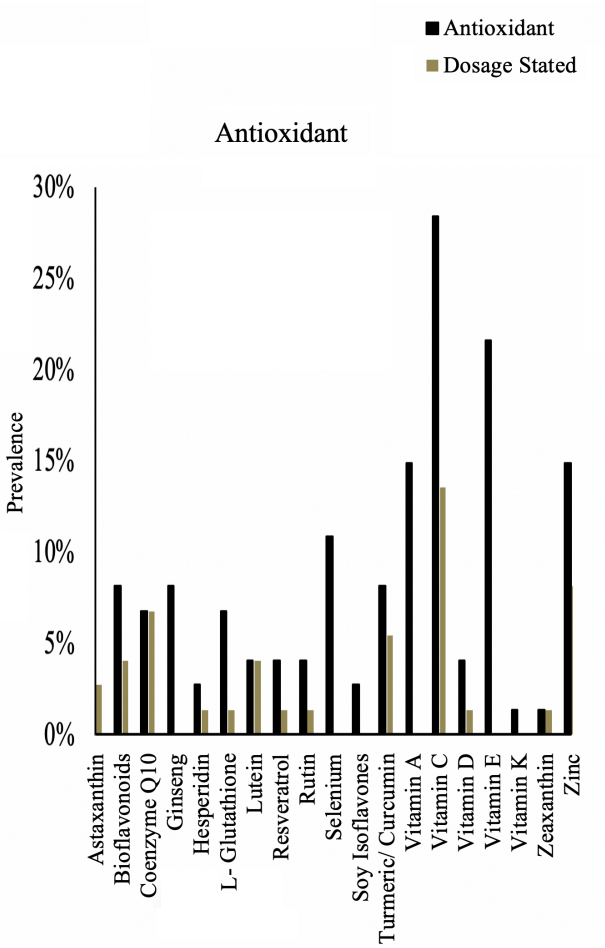

Figure 1 Prevalence of antioxidant compounds and their dosages as stated on the surveyed products' labels (*n*=74)

Table 1 Stated dosage (mg) of Antioxidant Compounds (*n*=74)

	Mean	Standard Deviation
Astaxanthin	5.00	1.41
Bioflavonoids	31.67	17.56
Coenzyme Q10/Ubiquinol	82.00	53.57
Ginseng	-	-
Hesperidin	12.50	0.00
L-Glutathione	10.00	0.00
Lutein	10.33	9.50
Resveratrol	160.00	0.00
Rutin	25.00	0.00
Selenium	-	-
Soy Isoflavones	-	-
Turmeric/Curcumin	493.75	748.03
Vitamin A	-	-
Vitamin C	436.84	420.57
Vitamin D	400.00	0.00
Vitamin E	-	-
Vitamin K	-	-
Zeaxanthin	2.00	0.00
Zinc	7.58	3.83

Colourings, flavours, sweeteners, and preservatives

Colouring was absent in 89.2% of the surveyed products. Titanium dioxide (E171) was the most used colouring (4.05%), followed by caramel (E150) (2.70%) and red iron oxide (E172ii) (2.70%) (**Fig. 2A**). Slightly less than half of the products (41.9%) were flavoured. Grape (14.9%), cranberry (8.1%), pomegranate (4.1%), and green tea (4.1%) were the most prevalent flavours (**Fig. 2B**). Most of the surveyed products (83.8%) were free from added sweeteners. Stevia was the most added sweetener (4.05%), followed by glucose (2.70%) and sorbitol (2.70%) (**Fig. 2C**). Added preservatives were totally absent from the surveyed products.

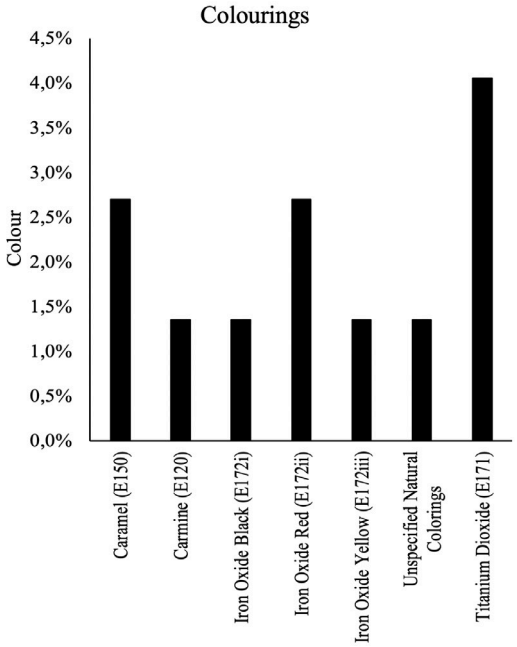

Figure 2A Prevalence of colourings used in surveyed products (*n*=74)

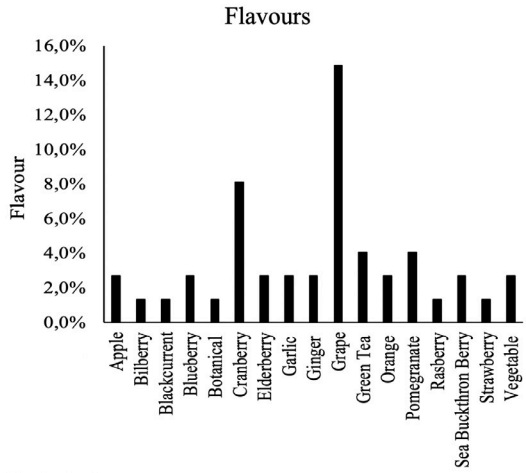

Figure 2B Prevalence of flavourings used in surveyed products (*n*=74)

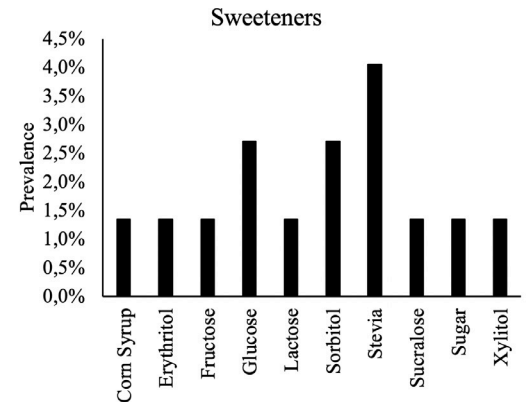

Figure 2C Prevalence of sweeteners used in surveyed products (*n*=74)

Health and non-health related claims

All the surveyed products stated the health claims on their labels, and these claims complied with the regulations stipulated by the Singapore Health Science Authority [6]. The health claims were categorized into 25 health domains (**Fig. 3A**). Antioxidant (43.2%), immunity (40.5%), skin health (24:3%), cardiovascular health (23.0%), and gut health (12.2%) comprised the top five health claims (**Fig. 3A**).

A total of 27 non-health related claims were stated on the labels of the surveyed products (**Fig. 3B**). Non-health related claims are statements made on specific product features not related to health benefits. The absence of gluten and wheat was listed on 50% of the products and was the most stated non-health related claim (**Fig. 3B**). The absence of artificial flavouring (41.9%), dairy, milk, and lactose (40.5%), preservatives (40.5%), and artificial colourings (39.2%) followed closely behind (**Fig. 3B**).

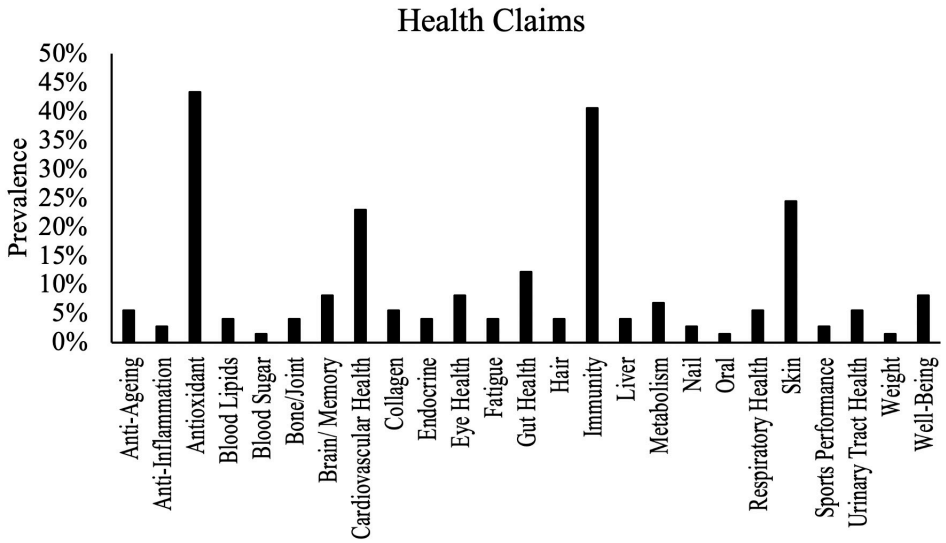

Figure 3A Prevalence of health claims stated on the surveyed products' labels (*n*=74)

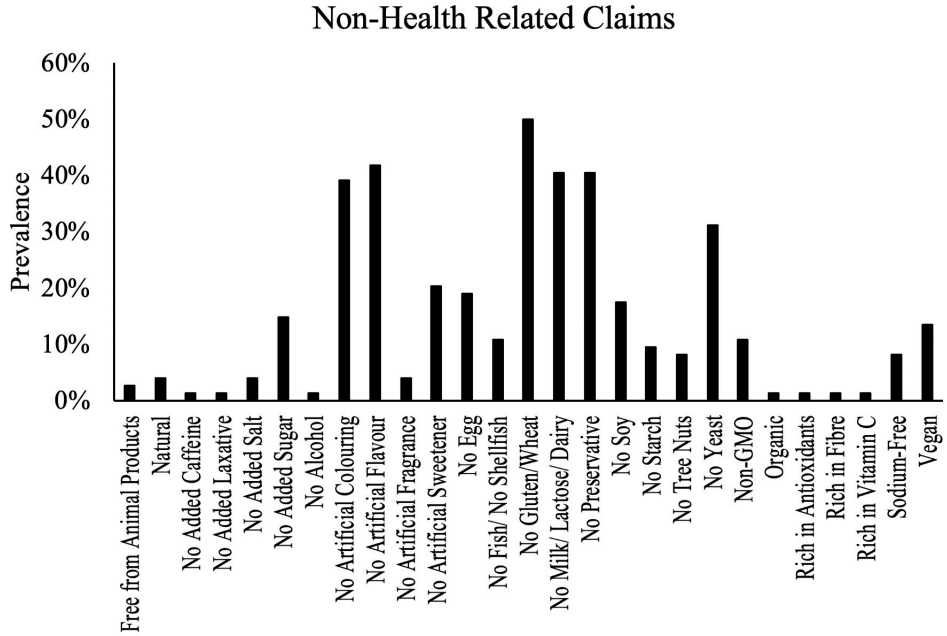

Figure 3B Prevalence of non-health related claims stated on the surveyed products' labels (*n*=74)

Discussion

The willingness to pay and purchase antioxidant health products depends on a consumer's level of involvement, consumer lifestyle as well as sensory and non-sensory attributes. Non-sensory attributes include a product's demography, such as price, brand, and country of origin and is affected by the trust of the health product or the credibility of its health and non-health related claims [7]. The surveyed products in this study were selected in equal numbers from physical and e-commerce retails. They originated from Asia, Australia/New Zealand, and the United States. Swallowable delivery forms, such as capsule, soft gel, and tablet, dominated. Gummies and jellies were slowly gaining popularity. The ease of consumption may be most likely drive these delivery formats [8]. Price has the biggest influence on willingness to purchase [9]. It can influence willingness to purchase in two ways: positively, if consumers experience an increase in the quality of the product, or negatively, if we consider the bigger material burden [9]. The mean cost of daily consumption equalled the cost of one cup of coffee at a local coffee shop and was considered as not priced above the average means of Singapore residents.

The health claims displayed on the packaging of antioxidant products are commonly used to illustrate and communicate the benefits of the product to consumers. According to the European Food Safety Authority (EFSA), "A health claim is any statement on labels, advertising or other marketing products that health benefits can result from consuming a given food, for instance that a food can help reinforce the body's natural defences or enhance learning ability" [10]. Research shows that health claims are necessary as they greatly influence consumers [11] and that even though some consumers tend to discount such messages, their scepticism towards health claims does not directly lower their willingness to purchase [12]. Health claims increase the value perceived by consumers, thus increasing their willingness to pay [13]. Messages relaying the positive effects of antioxidants have been shown to have a positive and significant effect on consumer choice [14]. The credibility of health claims may be influenced by the antioxidant ingredients, the source of the information, the product design, and the cultural beliefs of the consumers [7]. Rightfully, antioxidant action was the most prevalent health claim on the surveyed antioxidant health products. The recent increased popularity of natural food ingredients may prompt food manufacturers to replace synthetic antioxidants with natural antioxidative compounds. Natural antioxidants pose no health risk for consumers [15]. Sources of natural antioxidants are primarily of plant origins and occur in all parts of plants. Plants produce many natural antioxidants, such as vitamin C, tocopherols, carotenoids, and phenolic compounds, like flavonoids and phenolic acids [16]. Consumers generally believe that antioxidants present in food are natural antioxidants, regardless of whether the antioxidants are innately present or added during processing. Some antioxidant vitamins and minerals are popular with consumers and manufacturers because of their omnipresence in food. Lesser-known natural antioxidants, like phenolics, flavonoids, and polyphenols, require more consumer's awareness and education. Slightly more than one-fifth of the surveyed products did not state their antioxidant compositions. In addition, very few of the surveyed products stated the dosages of the antioxidant ingredients. Either the manufacturers chose to withhold this essential information or did not possess it. If the latter, it is also puzzling how the manufacturer can maintain its product consistency and integrity. Affluent consumers are beginning to pay attention to the specificities of health products, especially the active ingredient (antioxidants) amounts. It is the consumer's

right to know the exact compositions of antioxidants in the final product. Products with incomplete information about their composition and dosage of antioxidant ingredients greatly discounted the credibility of the product and may warrant the attention of the relevant regulatory authority.

Claims associated with immunity, skin, cardiovascular, and gut health were perceived by the manufacturers as being popular health claims with consumers. Boosting immunity or immune function is believed by many consumers to be critical in preventing illness and disease [17]. The recent COVID-19 pandemic is likely to encourage the sales of products associated with boosting the immune function [18]. Studies show that beauty and anti-ageing are also becoming valid reasons behind the purchase and consumption of health products [19]. Cardiovascular disease is the leading cause of death globally.[20] Though the disease may be prevented by eliminating behavioural risk factors such as tobacco use, unhealthy diet and obesity, physical inactivity and harmful use of alcohol, the consumption of antioxidant health products may be a welcoming strategy for some consumers looking for easier alternatives or more reassurance [21]. The recent discussion topics on the gut-brain and gut-heart connection focuses the attention of health-conscious affluent consumer on gut health maintenance [22, 23]. All the above common health claims are most likely connected to the antioxidant action of these products. Antioxidants, like vitamin C, vitamin E, zinc, selenium, and phenolic compounds, have been reported to contribute to human immune health [24, 25], skin health[26, 27], cardiovascular health [28, 29], and gut health [30].

Food allergens are food components that induce the production of IgE antibodies, resulting in immediate hypersensitive reactions [31]. Common food allergens include gluten, wheat, dairy and lactose [31]. It is critical for the safety of the consumers that manufacturers declare the presence of food allergens in their products [31]. The absence of food allergens also presents a unique non-health claim for the product and may explain the significantly high proportions of such food allergen absence claims in the surveyed antioxidant products. Additive-free claims, such as no artificial colouring, no artificial flavours, no preservatives, etc, made up the remainder of the non-health claims. Additives often are added to improve the sensory and storage qualities of the final products and increase the acceptance of these products by consumers [32].

Added colourants make the final product more visually appealing by giving colour to an otherwise colourless product, or by restoring the original appearance of a product [32]. The results of this study suggested that the visual appearance of the finished product is not of importance to consumers. Coupled with the recent negative publicity on the use of food additives [33], the manufacturers of the surveyed antioxidant products are more likely to avoid the use of food additives. In the pharmaceutical industry, titanium dioxide is used to add whiteness or accentuate the boldness of other colours [34]. It is an essential part of the protective coating required to preserve the safety, efficacy and quality of the active pharmaceutical ingredient and also provides shelf-life stability [34]. The titanium dioxide coating offers protection for photosensitive and ultraviolet-vulnerable ingredients [34]. It is not surprising, therefore, that titanium dioxide was the most popular colourant used in the surveyed products. Ironically, a recent review by the (EFSA) concluded that titanium dioxide can no longer be considered safe as a food additive [35]. A critical element in reaching this conclusion was that the review panel could not exclude genotoxicity concerns after consumption of titanium dioxide particles [35]. After oral ingestion, even though the absorption of titanium dioxide particles is low, they can accumulate in the body [35]. Though the

statement from the EFSA fell short of a total ban of titanium dioxide use in Europe, it informs the stakeholders (manufacturers and consumers) and policy makers when they decide upon possible regulatory actions [35]. Caramel colouring, which was used in 2.70% of the surveyed products, has been used as a food colouring in foods and beverages for over 150 years [36]. Unlike titanium dioxide, available studies conclude that caramel colours are not genotoxic or carcinogenic and current exposure estimates indicate that intake of caramel colours and constituents do not pose undue safety risks [36]. Red iron oxide, which was used in 2.70% of the surveyed products, may face a similar issue as titanium dioxide as nanoparticles have been detected in this approved food dye [37].

Flavour and sweetness are of lesser importance as the majority of surveyed products were delivered in swallowable forms such as capsule, tablet, and soft gel. This may explain why more than half the products were unflavoured, and most (83.8%) were unsweetened. Of the products that did contain sweetener, Stevia, being natural and noncaloric, was the most used (4.05%) and has been gaining popularity among the more informed consumers and manufacturers.

The study results were confined to the information the manufacturers chose to present on the product labels, though the label content is regulated by the local authority.

Conclusions

The credibility of an antioxidant product and its health claims will be severely discounted when the information about the composition and dosages of the antioxidants is incomplete. The choice of colourings should be reconsidered to prioritize consumer safety.

Conflict of Interests: None

References

1. Gulcin İ (2020) Antioxidants and antioxidant methods: an updated overview. Arch Toxicol 94:651–715
2. Marchio P *et al* (2019) Targeting early atherosclerosis: a focus on oxidative stress and inflammation. Oxidat Med Cell Longev. https://doi.org/10.1155/2019/8563845
3. Oguntibeju OO (2019) Type 2 diabetes mellitus, oxidative stress and inflammation: examining the links. Int J Physiol Pathophysiol Pharmacol 11:45–63
4. Jayedi A *et al* (2018) Dietary antioxidants, circulating antioxidant concentrations, total antioxidant capacity, and risk of all-cause mortality: A systematic review and dose-response meta-analysis of prospective observational studies. Adv Nutr 9:701–716
5. Nuzzo D (2021) Role of natural antioxidants on neuroprotection and neuroinflammation. Antioxidants (Basel) 10(4):608
6. Health Science Authority Singapore (2021) Health supplement claims. https://www.hsa.gov.sg/health-supplements/claims. Accessed 23 February 2022
7. Plasek B and Á Temesi (2019) The credibility of the effects of functional food products and consumers' willingness to purchase/willingness to pay – review. Appetite 143:104398–104405
8. Almukainzi M (2021) Assessment of oral solid dosage forms administration manner and acceptability. Pharmacia 68:393–400
9. Annunziata A and R Vecchio (2013) Consumer perception of functional foods: A conjoint analysis with probiotics. Food Qual Prefer 28:348–355
10. European Food Safety Authority (2022) Health Claims https://www.efsa.europa.eu/en/topics/topic/health-claims. Accessed 21 March 2022
11. Hirogaki M (2013) Estimating consumers' willingness to pay for health food claims: a conjoint analysis. Int J Innov Manage Technol 4:541–550
12. Gineikiene, Kiudyte and Degutis M (2017) Functional, organic or conventional? Food choices of health conscious and skeptical consumers. Balt J Manage 12:139–152
13. Vecchio R, Van Loo EJ, and Annunziata A (2016) Consumers' willingness to pay for conventional, organic and functional yogurt: evidence from experimental auctions. Int J Consum Studies 40:368–378

14. Zaikin AA and McCluskey JJ (2013) Consumer preferences for new technology: apples enriched with antioxidant coatings in Uzbekistan. Agric Econ 44:513–521

15. Shahidi F (2020) Food processing and effects on bioactive constituents: an opinion piece. J Food Bioact 12:1–2

16. Amarowicz R, Pegg RB (2019) Natural antioxidants of plant origin. Adv Food Nutr Res 90:1–81

17. Jayawardena R *et al* (2020) Enhancing immunity in viral infections, with special emphasis on COVID-19: a review. Diabetes Metab Syndr: Clin Res Rev 14:367–382

18. Wagner DN, Marcon AR, Caulfield T (2020) "Immune Boosting" in the time of COVID: selling immunity on Instagram. Allergy Asthma Clin Immunol 16:76–82

19. Calasanti T *et al* (2016) Rationales for anti-aging activities in middle age: aging, health, or appearance? Gerontologist 58(2):233–241

20. World Health Organization (2021) Cardiovascular Disease. https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-(cvds) Accessed 22 March 2022

21. Neha K *et al* (2019) Medicinal prospects of antioxidants: a review. Eur J Med Chem 178:687–704

22. Forkosh E and Ilan Y (2019) The heart-gut axis: new target for atherosclerosis and congestive heart failure therapy. Open Heart 6(1):e000993

23. Cryan JF *et al* (2019) The microbiota-gut-brain axis. Physiol Rev 99:1877–2013

24. Elmadfa I and Meyer AL (2019) The role of the status of selected micronutrients in shaping the immune function. Endocr Metab Immune Disord Drug Targets 19(8):1100–1115

25. Wu D, Meydani SN (2019) Antioxidants and immune function. In: Papas AM (ed) Antioxidant Status, Diet, Nutrition, and Health. CRC Press, pp.370–400

26. Dunaway S *et al* (2018) Natural antioxidants: multiple mechanisms to protect skin from solar radiation. Front Pharmacol 9:392–399.

27. Boo YC (2019) Can plant phenolic compounds protect the skin from airborne particulate matter? Antioxidants 8:379–385

28. Forman HJ and Zhang H (2021) Targeting oxidative stress in disease: promise and limitations of antioxidant therapy. Nature Rev Drug Discover 20:689–709

29. Aune D *et al* (2018) Dietary intake and blood concentrations of antioxidants and the risk of cardiovascular disease, total cancer, and all-cause mortality: a systematic review and dose-response meta-analysis of prospective studies. Am J Clin Nutr 108:1069–1091

30. Ballway JW and Song BJ (2021) Translational approaches with antioxidant phytochemicals against alcohol-mediated oxidative stress, gut dysbiosis, intestinal barrier dysfunction, and fatty liver disease. Antioxidants (Basel) 10(3):384–390

31. Schroer B *et al* (2021) Practical challenges and considerations for early introduction of potential food allergens for prevention of food allergy. J Allergy Clin Immunol Pract 9(1):44–56 e1

32. Chazelas E *et al* (2020) Food additives: distribution and co-occurrence in 126,000 food products of the French market. Sci Rep 10(1):3980–3985

33. Sundar A *et al* (2021) Is unnatural unhealthy? Think about it: overcoming negative halo effects from food labels. Psychol Market 38:1280–1292

34. Jovanović B (2015) Critical review of public health regulations of titanium dioxide, a human food additive. Integr Environ Assess Manag 11(1):10–20

35. European Food Safety Authority (2021) Safety assessment of titanium dioxide (E171) as a food additive. Eur Food Safety Auth 19:e06585

36. Vollmuth TA (2018) Caramel colour safety – an update. Food Chem Toxicol 111:578–596

37. Voss L *et al* (2020) The presence of iron oxide nanoparticles in the food pigment E172. Food Chem 327:127000–127010