

# Factors Determining Selection of Essential Nutrition Supplements

Daniel C. S. Lim

**Abstract**—There are numerous nutritional supplements, such as multivitamins and nutrition drinks, in the market today. Many of these supplements are expensive and tend to be driven commercially by business decisions and big marketing budgets. Many of the costs are ultimately borne by the end user in the quest for keeping to a healthy lifestyle. This paper proposes a system with a list of ten determinants to gauge how to decide the value of various supplements. It suggests variables such as composition, safety, efficacy and bioavailability, as well as several other considerations. These guidelines can help to tackle many of the issues that people of all ages face in the way that they receive essential nutrients. The system also aims to promote and improve the safety and choice of foods and supplements. In so doing, the system aims to promote the individual's or population's control over their own health and reduce the growing health care burden on the society.

**Keywords**—Nutritional supplements, vitamins and minerals, bioavailability, supplementation determinants, nutrition guidelines.

## I. INTRODUCTION

OVER the course of the 20<sup>th</sup> century, special factors that are essential to human and cellular health were being discovered. This enabled mankind for the first time to understand how these special factors interact in our bodies to provide everyday basic function and prevent diseases. The first mention of the word vitamin was recorded in 1912 [1]. This led to a slew of discoveries of the essential nutrients that are specifically linked to how all living things function physiologically. These discoveries also enabled scientists to recognize that many diseases were linked to nutritional deficiencies affecting basic organ function that led to decay faster than normal [2]. Chemists then discovered how to isolate various vitamins and deduced their chemical structures, and learned how to synthesize these for inclusion into what we know today as multivitamin supplements. With this, the field of nutrition was able to forge ahead to become more scientific in the approach to understanding the relationships between these essential nutrients and health-disease dogma.

Applications soon followed during the World War II where fortifications of several of these vitamins and minerals were used to fortify milk and other drinks [2]. This opened a market for multivitamin supplements towards the 1950s onwards in the West. Today, scientists have realized and are continuing to discover the interactions between the essential nutrients in the biosynthesis and pathways of the human system. The complexity of these interactions has led to combinatorial

chemistries for these nutrients in affecting these biomedical function outcomes [3].

Today, there are a great number of nutritional supplements available in the market. This paper aims to present an opinion of some of the factors that would affect decision making in terms of how some of these can be better understood and applied to general public nutrition and for nutritional therapies of diseases and medical conditions.

Presented here are ten deterministic factors that are proposed as reference when considering or ranking nutritional supplements for their intended purposes of benefitting health through ingestion as food or drink.

## II. DETERMINISTIC FACTORS

This section presents some of the factors that would be considered important when judging a nutritional supplement for value and effectiveness. These factors are as follows:

### A. Constitution

This deterministic factor assesses the composition and ensures the presence of all the essential nutrients that the body requires to function well. The essential macro/micronutrients generally cannot be made by the body or synthesized in insufficient quantities [4]. Because of modern understanding of how various nutrients are dependent on several others to make them effective, it is proposed that having the full spectrum of essential nutrients in a supplement is considered more favorably than the presence of some with others amiss.

For the constitution of the nutritional supplement to be complete, it must contain all the essential nutrients that the body requires to attain optimal organ function. These would include the macronutrients: proteins, carbohydrates and oils, as well as the full spectrum of micronutrients: 13 vitamins and at least a similar number of minerals. This factor is determined by assessing that all these critical essential nutrients are complete and present in the supplement. These essential nutrients generally do not work in isolation when maintaining optimum cell and organ function but in synergy with one another [5].

Constitution of a supplement also considers what other ingredients are added to the group of essential nutrients, usually for more specified purposes. Examples include glucosamine for joint health in relation to formulations for seniors or for high impact sports, or in some cases a traditional Chinese medicine ingredient to improve energy flow [6].

### B. Bioavailability

This deterministic factor assesses the proportion of nutrients or combination of nutrients from the supplement that can be

D. C. S. Lim is with the Society of Nutrition, Health & Fitness, Singapore (phone: 65-90276698; e-mail: lim.cs.daniel@gmail.com).

absorbed and used by the body for their intended purposes [7], [8]. Nutrients that are bioavailable are more easily and effectively used by the body. When the supplement enters the body, it goes through different stages of the metabolic pathway, whereby the nutrient undergoes transformation, thus changing the nutrient bioavailability. Such stages could be as follows: (a) nutrient release from the physicochemical supplemental matrix, (b) digestive enzymatic effects in the intestine, (c) intestinal mucosa binding and uptake, (d) transfer across the cellular wall of the gut to the circulatory system, (e) distribution across the systemic network, (f) deposition and storage at various sites, (g) metabolic and functional usage, and (h) wasting via excreta. Although much of the above is dependent on the person's physiological status such as age, gender, health condition, life stage (e.g. pregnancy) [9], the focus here is on applying the preferred form of the nutrient in the supplement. Preferred forms can refer to amino acids chelates, mixed carotenoids, or organic acid complexes.

Macronutrients such as carbohydrates, proteins, fats are easily absorbed and utilized with 90% bioavailability. In contrast, there is a greater variation in the bioavailability of micronutrients such as vitamins, minerals, and bioactive phytochemicals.

The existence of food nutrients such as minerals in various chemical forms is one of the factors influencing the bioavailability of these nutrients. For example, haem and non-haem iron are two forms of dietary iron. Haem iron is derived only from animal origin, whereas the non-haem form of iron is derived both from plants and animal sources. Haem iron is found mainly in hemoglobin and myoglobin molecules which are essential for transporting and storing oxygen in the blood and muscles respectively. When released from the food by digestive factors, the haem molecule acts like a protective ring around the bound iron. Thus, the iron is protected from nutrient interactions, remaining soluble in the intestine, and is completely absorbed through a specific transport system on the intestinal surface [10]. However, non-haem iron is not as soluble as haem iron under normal digestion in the intestines and is easily affected by nutrient-nutrient-interactions. Hence, only a small proportion is absorbed by the cells.

Sometimes, the nutrient content in foods is increased via a process called fortification where vitamins and minerals are added to the foods. For example, folic acid, a synthetic form of dietary folate is often added to breakfast cereals, flour, and certain spreads. This is due to folic acid being more bioavailable than dietary folate as based on many studies, and dietary folate from food is 20-70% less bioavailable than synthetic folic acid [11].

#### *C. Formulation Synergy*

Once one establishes the presence of constituents in the supplement, we can next look at whether the formulation is synergized to suit its intended purpose. This could be for general health and immunity, or more specific targeted weight loss and sports performance, or even medical support such as diabetes or even cancer. Since no essential nutrient works alone [3], this deterministic factor looks at the established

ratios and considerations to which the supplement is formulated based on the synergy of the ingredients and nutrients and the balance within the supplement. It also considers how and to what extent was the synergistic combinations considered, whether such combinations produce negative side effects or include considerations such as constructive antagonism [5] that prevents or subdues the side effects produced by the combination of constitutional ingredients.

#### *D. Formulation Stability*

Formulations should be checked and tested for stability. Stability here refers to the supplement in question retaining its efficacy for the intended function under the stated environmental and application conditions. Supplements chemical structures can be affected such that the intended purposes are altered, and the overall efficacy is lost. In the mid-20<sup>th</sup> century, water activity such as moisture was first proposed as a determinant for food stability. Today, this general concept is still used although it has its limitations that the applications may not be across the board. Thus, concepts such as water activity and glass transition concepts can complement the assessment of the supplement stability. Defining conditions such as critical temperatures for stability and then relating it with the content of water, as well as other considerations, can be tested to determine this stability criteria [12].

#### *E. Ease of Consumption*

The ease of consumption is important from the point that the nutritional supplement then becomes more effective in terms of pervasiveness of use. Diet-related chronic diseases are becoming more epidemic largely because of the food nutrition ecosystem availability. For most of the population, most food choices are made based on convenience and ease of availability. As such, fast foods have quickly become popular over the last century [13] and a common nutritional grazing pasture for the masses. As such, one of the considerations is to assess ease of consumption. For example, a baby supplement configured in the form of a large pill would rank bottom. On the other hand, a supplement that can be truly configured as a drink or food medium will rank highly.

#### *F. Safety*

Supplement safety pertains to the scientific discipline involving and revolving around its handling, preparation, storage, formulation and consumption in a way that would prevent illness [14]. This is another very important determinant. Many of these concerns can be addressed by time-tested, well-trusted authorities issuing these regulatory marks. Safety standards can greatly vary from country to country, company to company. So generally, the selection process should look out for regulatory stamps of approval that help ensure a mark of safety. Clear directions into the use and danger warnings of side effects should also be stated on the label. Determine whether scientific and clinical trials were carried out and how the methodologies of the tests were done as much as possible.

Ascertain whether there are programs or instructions that inform the user of the proper use of the product(s). Ultimately, the time and experience of the product is also a good determinant for safety.

Dose safety is also a concern. Some oil-soluble vitamins can stay in the body for months at a time. This could lead to over toxicity of that vitamin and the related negative side effect [15]. Combinations of how the various constituents might interact with each other can cause safety concerns as well [5].

Another aspect of safety is whether the supplement does what it promises in a safe way. For example, weight loss can be achieved very quickly by promoting losses in bone mass, muscle mass and water mass. Some supplements use camouflaging tactics that alter the body's recognition of fat, so that one can eat fat but that passes right through the body without being used. Another example is to fill the stomach with protein to address satiety, yet with no other key nutrients, the bone density decays over time. Thus, whilst the weight loss may be achieved swiftly, this comes with negative consequences such as later-life osteoporosis, weaker heart, hormonal imbalances, and so on. Thus, safety here would assess the types, magnitude, and dangers of the related side effects.

#### *G. Effectiveness*

This determinant looks at the efficacy in achieving the intended purpose, e.g. a supplement for the purpose of boosting immunity, organ function or performance. Although this has considerations relating to bioavailability and combinatory synergy of the various components, we are looking at efficacy as the achievement of specific outcomes. Again, a reminder here is that whilst some supplements may work, the side effects may still not be safe.

#### *H. Packaging*

This determinant looks at the overall packaging, particularly quality, packaging material, longer-term stability of the packaging material and whether material leeching to the nutritional products would occur. Safety seals are also important to guarantee the user that he or she is opening it for the first time after leaving the manufacturer and this ensures that the package has not been tampered with.

#### *I. Technologies*

Technologies refer to whether any key innovation that enhances the supplement is involved. For example, by synergizing the formula well, use of lower amounts of the nutrients to give the same impact as one that uses higher amounts of nutrients would provide safer and better alternative. Also, several nutritional supplements utilize the shaker tumbler and tumbler formulation to entrap oxygen into the activated drink, or some have special dispensers, or taste bud activators for diabetic formulas so that it tastes acceptable even without the use of table sugar or salt [5], [16]. Such technologies that help to provide more for less or make taking the supplement more convenient will rank highly here.

#### *J. Any Other Factors*

This pertains to any other factors that should be considered but have not been included in the above. Examples of this include the price-to-quality ratio or affordability criteria, societal adoption factors (e.g. beauty or coolness factors), ease of availability (e.g. easily bought from the nearby supermarket or delivery services). This deterministic consideration can also include the long-standing trusted brand, a well-known top scientist nutritionist or well-regarded formulator or relevant multidisciplinary team behind the formulation which will rank higher. The list is not exhaustive and can be extended.

### III. DISCUSSION

Nutritional supplementation is significantly finding importance over and above our daily food intake because of the impending malnutrition crisis faced in the developed and developing world. By not supplementing our food, it is hard and sometimes even impossible to find foods with the complete nutrition in the right synergistic mix [3]. Even whole foods, including fresh vegetables and fruits, have lost much of the nutrient contents and levels that they once had [5], [17]. Ignoring this trends would result in more sicknesses and chronic diseases. The health burden in the society and chronic diseases amongst younger adults are on the uptrend [5].

Choosing the right supplements that work and are effective is thus of growing importance. This paper presented some of the factors that one might consider using as a guide for choosing suitable and effective supplementation. Although this author recognizes that everyone has his/her own preferences and adaptations, the major focus here was on the general western world understanding of essential nutrition requirements.

Whilst there is no perfect way to judge the best nutritional supplement, the ten determinants presented can be used as a guideline. Weightages can be applied to these factors, and the sum-total score can be taken. Also, more important determinants can be assigned higher weightages, and vice-versa. Weightages may vary because supplementation formulas also largely depend on the application or intended purpose.

Although some of the determinants can be more difficult to determine quantitatively in a true sense (e.g. synergism, bioavailability or efficacy), these can still present themselves as a qualitative consideration. For example, if the supplement manufacturer or distributor can discuss openly about how the synergism or efficacy is determined, then it purports to have understood to some level the essence of that consideration.

### IV. CONCLUSIONS

In conclusion, nutritional supplementation in addition to our daily food is growing importance to curtail many of the chronic diseases that our modern societies are facing and prevent this epidemic. This paper lists several important determinants when comparing nutritional supplements. Assigned weightages of determinants relative to the others in terms of importance can produce quantitative indicators to

help with decision making.

#### ACKNOWLEDGMENT

The author wishes to thank the Society of Nutrition, Health & Fitness in Singapore for commissioning and sponsoring this work. The author is grateful for the feedback given by its members towards many of the points in the endeavor to assist members of the public to make more informed choices and effectively deploy their resources a little better in their quest for a healthier lifestyle.

#### REFERENCES

- [1] R. D. Semba, "The discovery of vitamins", *International Journal of Vitamins and Nutrition Research*, vol. 82, pp. 310-315, 2013. DOI: 10.1024/0300-9831/a000124.
- [2] I. J. Martins, "Diabetes and organ dysfunction in the developing and developed world", *Global Journal of Medical Research F*, vol. 15, no. 1, 2015.
- [3] D. C. S. Lim, E.Y. M. Yeo and W. Y. Tan, "Combinatory Nutrition Supplementation – a case for increasing calcium bioavailability", World Academy of Science, Engineering and Technology Conference on Nutrition, Kuala Lumpur, Malaysia, 2017.
- [4] T. Kobark, "Essential nutrition", eds. W. Mitchell, C. Mach and C. Mitchell, Intellectual Properties Publ., 2011, San Diego, USA.
- [5] D. C. S. Lim, "Nutrition supplementation as a strategic asset", *Cloud Futures Economic Forum*, Sept 2016, Wuxi, China.
- [6] D. Bensky, "Chinese herbal medicine: materia medica", *Eastland Press*, 2004.
- [7] B. Holst, G. Williamson, "Nutrients and phytochemicals: from bioavailability to bioefficacy beyond antioxidants", *Current Opinion in Biotechnology*, vol.19, pp.73-82, 2008.
- [8] P. J. Aggett, "Population reference intakes and micronutrient bioavailability: a European perspective", *American Journal of Clinical Nutrition*, vol. 91(suppl), pp. 1433S-1437S.
- [9] M. Shayeghi, G. O. Latunde-Dada, J.S. Oakhill, A. H. Laftah, K. Takeuchi, N. Halliday, Y. Khan, A. Warley, F.E. McCann, R.C. Hider, D.M. Frazer, G.J. Anderson, C.D. Vulpe, R.J. Simpson, A.T. McKie, "Identification of an intestinal heme transporter", *Cell*, vol. 122, no.5, pp. 789-801, 2015.
- [10] M.P. Hannon-Fletcher, N.C. Armstrong, J.M. Scott, K. Pentieva, I. Bradbury, M. Ward, J.J. Strain, A.A. Dunn, A.M. Molloy, M.A. Kerr, H. McNulty, "Determining bioavailability of food folates in a controlled intervention study", *American Journal of Clinical Nutrition*, vol. 80, no.4, pp. 911-918, 2005.
- [11] R. M. Winkels, I. A. Brouwer, E. Siebelink, M. B. Katan, P. Verhoef, "Bioavailability of food folates is 80% of that of folic acid", *American Journal of Clinical Nutrition*, vol. 85, no. 2, pp. 465-473, 2007.
- [12] M. S. Rahman, "Food stability determined by macro-micro region concept in the state diagram and by defining a critical temperature", *Journal of Food Engineering*, vol 99, is 4, pp412 – 416, 2010.
- [13] S. A. French, M. Story, D. Neumark-Sztainer, J. A. Fulke Hannan, "Fast food restaurant use among adolescents: with nutrient intake, food choices and behavior psycho-social variables", *International Journal of Obesity*, vol. 25, no.12, pp. 1823-1833, 2001.
- [14] USDA, "Food safety", <https://www.usda.gov/wps/portal/usda/>. Accessed on 28 October 2016.
- [15] K. L. Penniston, S. A. Tanumihardjo, "The acute and chronic toxic effects of vitamin A1,2,3,4", *The American Journal of Clinical Nutrition*, vol. 83, no. 2, pp. 191-201, 2006.
- [16] Café Seventy, <http://www.cafeseventy.com> accessed on 29 October 2016.
- [17] C.L. Rock, J. L. Loalvo, C. Emenhiser, M.T. Ruffin, S.W. Flatt, S.J. Schwartz, "Bioavailability of  $\beta$ -carotene is lower in raw than in processed carrots and spinach in women", *The Journal of Nutrition*, vol. 128, no. 5, pp. 913-916, 1998.