

# Why Supplement?

The Unexpected Benefits  
of Natural Products

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On the thriving but complex health and wellness market, busy consumers want multi-purpose solutions to their health concerns. **Pauline Huang**, Rousselot, explores how collagen peptides are emerging as an all-in-one solution to consumers' demand for a holistic approach to their supplementation.



## 11 Nutritional Intervention to Exposure to Air Pollution

Exposure to indoor and urban air pollution is estimated to be responsible for 3.1 million deaths annually, but some nutritional ingredients have been shown to target some responses to exposure in humans. **Dr Weiguo Zhang** explains the research behind these health benefits and calls for a worldwide reduction in air pollution.

## 16 Fortifying for the Future: How Staple Food Fortification Can Help Tackle Hidden Hunger Worldwide

Shortages in adequate vitamin and mineral intake have led to a rising incidence of 'hidden hunger' and staple food fortification is emerging as an effective solution to achieving the United Nation's goal of Zero Hunger by 2030. **Sarah Louis** covers the impact of malnutrition and the ways staple food fortification programs are helping those in need.

## 21 Takeaways

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# More Than Optimal Health

**A** **At first glance**, the question ‘why supplement?’ seems both redundant and apparent to the nutraceutical and functional food industry. To consumers, supplementation can seem both obvious and bewildering; this curious dichotomy explains the need to ask the question. We could spend hours extolling the benefits of our ingredients in supporting optimal health, but this issue goes a bit deeper. Here, we’re exploring the unexpected and little-discussed benefits of supplementation.

We kick off with a look at a source of consumer confusion; ingredients like collagen have a multitude of health benefits, but tend to be consumed for a single purpose. As lifestyles change, consumers demand supplements that address all their health concerns at once; little do they know, they already have plenty of ingredients that can do this! Pauline Huang uses collagen as an example in discussing the rise of all-in-one health supplements on [page 5](#).

My news bulletin every morning tells me the current pollution levels in London—and every day, it’s a scary number. According to the World Health Organization, exposure to air pollution is estimated to be responsible for 3.1 million deaths annually and particulate matter of 2.5 micrometres is of notable concern. Fortunately, as Dr Weiguo Zhang explains on [page 11](#), common nutrients have been shown to help fend off the adverse effects of air pollution.

Another result of modern lifestyles is diets around the world moving away from nutrient-dense foods, which has resulted in nutrient deficiency reaching epidemic levels. This ‘hidden hunger’ is present around the world, and there are plenty of places where people don’t have access to supplements that could meet this shortfall. As inadequate nutrition can have a major impact on human health and development, staple food fortification programs are emerging as a vital part of eradicating hidden hunger. In her article on [page 16](#), Sarah Louis examines the effects of malnutrition and the ways fortification can make a real difference.

As an industry, we push towards optimal health for our consumer—which is great! But it’s easy to say everyone should take nutritional supplements; the challenge is in communicating why.



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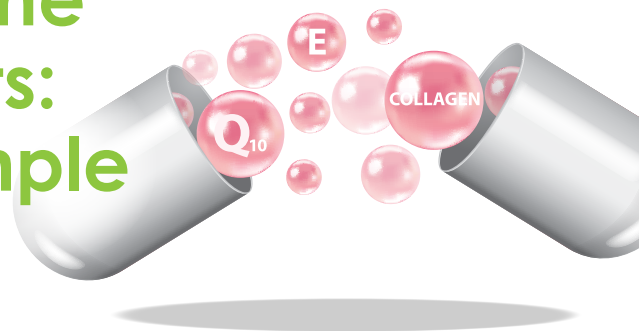
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# The Rise of All-in-One Health Supplements: The Collagen Example



by *Pauline Huang*

**In the thriving, but complex**, health and wellness market, busy consumers want multi-purpose solutions.

As lifestyles and mentalities change and the pace of life goes up, consumers increasingly want foods, drinks and supplements that address all their individual health concerns at once.<sup>1</sup> This holistic approach to health and wellness is evident in the increased focus on exercise, relaxation, personal care, therapy and coaching. Against this backdrop, collagen peptides are emerging as a relatively simple but highly convincing solution. Although traditionally used in skin care products, a steady flow of scientific studies reveals this naturally occurring protein has a wide range of health benefits. It is the kind of all-in-one solution consumers crave.

## Keeping up, staying young

The world we live in today bears little resemblance to the one many of us were born into. Technological, economic, demographic and social developments have transformed the way we live, work and enjoy life—faster-paced living as a mega-trend is here to stay.

As public health awareness improves, consumers are learning their diet can help them keep up with the demands of modern life. Healthy eating is no longer the exclusive domain of people trying to manage their weight or fill nutritional gaps. It has become engrained in our everyday habits: more than ever, it is understood to support both mental and physical wellbeing at every stage of life. This includes the later stages of life; improvements in medicine and living conditions are enabling us to live longer. Although chronic diseases are appearing earlier on in life, consumers do not want to ‘slow down’.

Instead, they expect solutions to age-related health conditions, such as mobility issues resulting from a decrease in muscle mass and bone density and the ageing of cartilage. On top of that, in this era of ‘having it all’, ageing people want to retain a youthful appearance—for many, fine lines and wrinkles are an unwelcome arrival to be delayed for as long as possible.

Meanwhile, governments are cutting national healthcare budgets and pushing for healthier lifestyles, with a growing focus on health issues in the media and online.



## Health & wellness, an exciting growth market

The desire to look and feel great throughout our lives is a major driver of the thriving health and wellness market, which has enjoyed years of uninterrupted growth. Euromonitor predicts that it will reach a value of US\$833B by 2021.<sup>1</sup> And according to Technavio, the health and wellness segment now accounts for more than half of the world's food industry<sup>2</sup>—a share set to grow still further in the coming years. This presents a huge opportunity for providers of nutraceuticals and healthy food and drinks. With that opportunity comes the challenge of selecting ingredients to provide the desired (multi-)functionality, performance and taste.

### Consumers in control

As a result of these developments, consumers' health awareness is increasing and people are more comfortable seeking information to improve their health, such as searching online or visiting pharmacists for advice on particular OTC products.<sup>3</sup>

Attitudes towards health and illness are also shifting. Rather than treating symptoms when they occur, people are increasingly eager to optimise their health and wellness. They are looking to improve their health by adopting a healthier lifestyle through exercise, diet and healthcare products. This is creating a proactive demand for preventive measures and opening the door to health ingredients that target multiple health benefits and support overall wellbeing.<sup>3</sup>

### From single- to multi-purpose solutions

Historically, dietary supplements were designed to address one specific condition or health concern. This approach is no longer fully in tune with consumers' wishes. Increasingly, they prefer foods, drinks and supplements with multiple benefits—a holistic approach that resonates with consumers' ideals and saves them precious time and energy, too: although consumers know they should eat healthily and are highly motivated to do so, they rarely have the time or motivation to seek out numerous products to address all their individual health concerns or goals.

Achieving multiple benefits with a single product can be difficult. The bar is raised further by the trend towards clean labels, which means formulators must choose their ingredients carefully to ensure consumer acceptance. Natural, rather than artificial, ingredients are a top priority. People also want terms they recognise and value a short, comprehensible ingredients list. In addition to that, demand for scientific backing is high: health and wellness ingredients need to be proven to be effective through scientific research and (preferably independent) clinical trials.

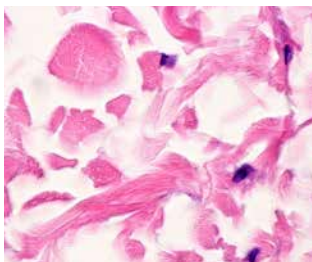
### The (re)discovery of collagen peptides

Developing health and wellness products that meet these diverse requirements might appear a daunting challenge. One ingredient is emerging as a relatively simple, but convincing solution to today's exacting consumer demands. Collagen peptides are not new, but thanks to their

alignment with many current nutrition trends—including protein enrichment, more active lifestyles, clean or natural eating, and beauty from within—they are one of the industry's fastest-growing ingredients. Nutrition Business Journal (NBJ) preliminarily estimates collagen sales went up by 7.2 percent over 2016-2017, reaching US\$1.1 billion in 2017, with sales projected to continue growing at a similar pace.<sup>4</sup>

Collagen peptides are a hydrolysed form of collagen, which is the most abundant protein occurring naturally in the human body. Collagen is a key structural protein that ensures the cohesion, elasticity and regeneration of all connective tissues, including skin, cartilage, tendons, ligaments, muscles and bones. From the age of 30, less collagen is produced by the body. This can lead to loss of skin elasticity and firmness, cartilage degeneration, joint stiffness, muscle mass reduction and lower bone mineral density and strength. The consumption of collagen peptides can have a positive effect on these regressive processes. The small peptides are transported from the gut via the blood to different parts of the body,<sup>5,6</sup> and help boost the level of structural collagen in the target tissues—supplying the body with the amino acids needed as building blocks to renew tissues.

It has been proposed collagen peptides may also act as a messenger to the cells and trigger the synthesis and reorganisation of new collagen fibres, therefore supporting tissue structure.



**Collagen** is a key structural protein that ensures the cohesion, elasticity and regeneration of all connective tissues, including skin, cartilage, tendons, ligaments, muscles and bones.

Collagen has traditionally been widely used as an active ingredient in skin beauty products, starting decades ago in Japan, then gradually maturing in Europe and now starting to make its way onto the US market. Nowadays, its effectiveness in supporting bone and joint health and sports nutritional needs is also being acknowledged. But the use of collagen for health purposes has been documented as far back as the 12th century. Abbess and universal scholar Hildegard von Bingen recommended frequent intake of bone broth to help relieve joint discomfort. Fast-forward a couple of centuries to the Napoleonic Wars, and collagen in bone broth was used as a primary source of protein when meat became scarce.<sup>7</sup>

With its ancient heritage and today's scientific evidence backing its holistic health benefits, collagen is becoming the superfood more and more consumers are talking about.

### **Skin beauty**

The multiple health benefits of collagen peptides have been widely researched worldwide. For skin health, research has shown oral intake of collagen peptides may act to trigger the synthesis of new collagen fibres by stimulating fibroblasts.<sup>8,9</sup> These are the skin cells responsible for collagen production. With collagen accounting for 70 percent of dry mass skin content,



improved fibroblast action can have a significant impact on skin appearance. In other studies, daily intake of collagen peptides reduced collagen fragmentation by 31 percent, enhanced skin moisture levels by 28 percent,<sup>10</sup> helped repair damage caused by UV radiation<sup>11</sup> and reduced the visible signs of ageing,<sup>12</sup> such as dehydration, fine lines and wrinkles.<sup>13</sup>

### Mobility

Collagen peptides support multiple mobility related areas including joints, connective tissue structure and bones.

Joint health studies dating back nearly 20 years demonstrate a range of benefits, including the relief of discomfort.<sup>14,15,16</sup> For instance, a major double-blind, placebo-controlled clinical study on elderly women suffering from knee joint problems recorded a 32 percent reduction of joint pain, a 44 percent reduction of stiffness and a 22 percent improvement in function among participants who regularly consumed collagen peptides.<sup>17</sup> More recently, an in vivo study conducted at the University of Rochester demonstrated collagen peptides' capacity to dose-dependently preserve cartilage and to support extracellular matrix regeneration by stimulating the production of proteoglycans, the matrix components involved in joint lubrication.<sup>18</sup>



### Synovial membrane in collagen peptide-treated animals

showed significantly lower levels of TNF, a protein signalling inflammation, compared to the control group at both early and mid-stage disease.

A common symptom of joint inflammation during osteoarthritis development is a thickening of the synovial membrane which surrounds the knee. In the same study<sup>18</sup> there was a significant reduction of the thickening of this membrane in the collagen peptide groups. Furthermore, the synovial membrane in collagen peptide-treated animals showed significantly lower levels of TNF, a protein signalling inflammation, compared to the control group at both early and mid-stage disease. Providing further compelling evidence and clarifying collagen peptides' unique capacity to reduce inflammation, these results are particularly important in the light of the fact that inflammation is one of the main causes of joint discomfort.





Having strong connective tissue structures, including tendons and ligaments, is very important to consumers who pursue an active lifestyle. It is even more important for sportspeople who need to be protected from injuries. An in vivo study demonstrated a significant increase in the collagen fibril diameter of the Achilles tendon after participants took collagen peptides supplements for eight weeks.<sup>19</sup> In a large-scale study of different categories of athletes, those taking a mix of collagen peptides, BCAA and arginine over a period of two years experienced a decrease in tendon, ligament, joint and muscle injury rate.<sup>20</sup> A smaller, placebo-controlled study<sup>21</sup> confirmed consuming collagen with vitamin C, followed by a burst of intensive exercise, can help build ligaments, tendons and bones, and likely plays a beneficial role in injury prevention and tissue repair. Additional clinical evidence on injury prevention on athletes is reported by Baar, 2015,<sup>22</sup> and Ribas-Fernandez, 1998.<sup>23</sup>

### **Bone health**

Bone health is another area in which collagen peptides can provide convincing nutritional support. According to a recent consumer survey conducted by Innova, bone health is one of the top concerns for UK and US consumers.<sup>24</sup> Key to musculoskeletal strength, collagen peptides have been shown to boost bone mineral density,<sup>25</sup> help prevent bone loss<sup>26</sup> and improve osteoblast differentiation,<sup>27,28</sup> shifting the bone metabolism balance towards bone building.<sup>29,30</sup> As well as supporting strong and healthy bones, collagen peptides can boost the benefits of dietary calcium, improving its absorption, helping bones retain high levels of calcium, increasing bone mineral density and preserving bone strength, according to a 2015 in vivo study.<sup>31</sup>

The large number of benefits collagen peptides offer both consumers and food and supplement manufacturers make it easy to see why the popularity of this natural ingredient has rocketed in recent years. ●

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# Nutritional Intervention to Minimise the Harmful Effects of Exposure to Air Pollution

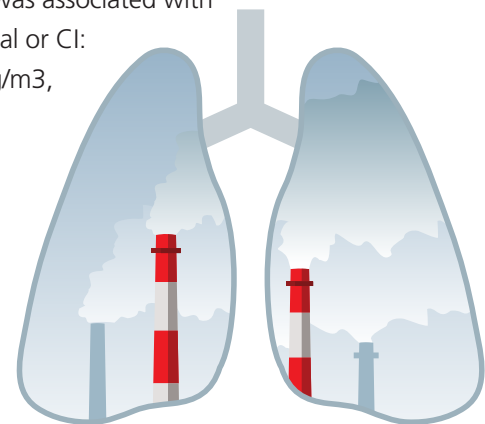
by Dr Weiguo Zhang

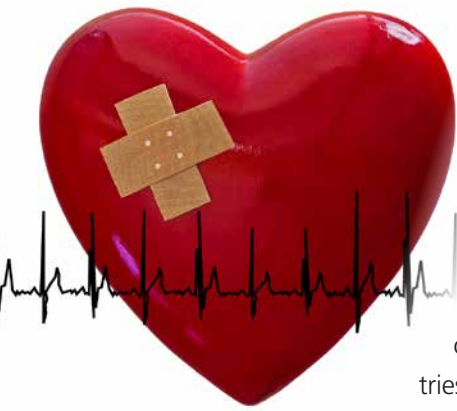
**M**ajor environmental contaminants in the atmosphere include particulate matter (PM), sulphur dioxide (SO<sub>2</sub>), nitrogen dioxide (NO<sub>2</sub>), carbon dioxide (CO<sub>2</sub>) and ozone (NO<sub>3</sub>). Among these pollutants, particulate matter with an aerodynamic diameter of less than 2.5 micrometres is called PM<sub>2.5</sub> and is of notable concern. Although these fine airborne particles are approximately 25 to 30 times smaller than the breadth of a human hair, they are a complex mixture of solid and liquid components—with organic and inorganic molecules including sulphate, nitrates, ammonia, sodium chloride, carbon, mineral dust and water. These fine particles are emitted from various sources, such as fossil-fuelled power stations, vehicles driven by a fuel combustion engine, forest fires, agricultural burning, and residential burning of wood, oil or coal, as well as dust storms and volcanic eruptions.

According to air quality guidelines (AQGs) published in 2005 by the World Health Organization (WHO), the lowest concentrations of ambient PM<sub>2.5</sub> should aimed for, defined as 10 µg/m<sup>3</sup> annually (or 25 µg/m<sup>3</sup> for any given 24-hour period). In 2016, WHO estimated over 90 percent of the world's population lived in places where air quality levels exceeded the limits of global AQGs.

## What does PM<sub>2.5</sub> do to human health?

Exposure to indoor and urban outdoor air pollution is estimated to be responsible for 3.1 million deaths annually, which comprises 3.2 percent of the global burden of disease.<sup>1</sup> In 2016 alone, the exposure to ambient (i.e. outdoor) air pollution caused 4.2 million premature deaths worldwide.<sup>2</sup> Among airborne pollutants, PM<sub>2.5</sub> is particularly dangerous because it can carry many toxic substances and lodge deep in the alveoli—the tiny sacs where the tracheobronchial tree ends in the lungs and the basic ventilation units where gas-blood exchange takes place. It was found that between 2000 and 2012, an increase of 10 µg/m<sup>3</sup> in PM<sub>2.5</sub> was associated with a 7.3 percent increase in all-cause mortality (95 percent confidence interval or CI: 7.1 to 7.5); in further analysis, with exposure to PM<sub>2.5</sub> of less than 12 µg/m<sup>3</sup>, the same increase in PM<sub>2.5</sub> was associated with 13.6 percent increase in death risk (95 percent CI: 13.1 to 14.1). A mounting body of evidence suggests the air pollution-induced increase in mortality is caused by pathogenesis of various diseases, particularly respiratory and cardiovascular diseases. An increase of 10 µg/m<sup>3</sup> in same-day PM<sub>2.5</sub> was associated with 0.47 percent (95 percent CI: 0.34-0.61) increase in cardiovascular mortality and a 0.57 percent (95 percent CI: 0.28-0.86) increase in respiratory mortality. A meta-analysis from ESCAPE showed





a statistically significant association between risk for lung cancer and PM2.5 concentration: the hazard ratio (HR) was 1.18 (95 percent CI: 0.96-1.46) per 5  $\mu\text{g}/\text{m}^3$  increase in PM2.5; for lung adenocarcinomas, the HR was 1.55 (95 percent CI: 1.05-2.29) with the same increment of PM2.5.

Heart rate variability (HRV) or cardiac cycle length variability is derived from electrocardiogram (ECG). HRV measures the time intervals of oscillations between consecutive heartbeats, largely reflecting how the heart tries to adjust in a beat-to-beat fashion in response to internal and external environment changes. Generally, HRV declines with ageing and some chronic diseases outcomes, thereby predicting poorer health outcomes—in clinical settings, a reduction of HRV predicts adverse cardiovascular events including ventricular arrhythmia, sudden cardiac death and myocardial infarction. The standard deviations of normal-to-normal intervals (SDNN) is one of the common and important indices of HRV, representing the time-domain differences of cardiac cycles, which is repeatedly found to be reduced in those who have been exposed to PM2.5.

Pathologically, PM2.5 may facilitate the development of arterial sclerosis. In the Multi-Ethnic Study of Atherosclerosis (MESA)<sup>3</sup> with 5,362 subjects aged over 60, the intima-medial thickness (IMT) of the carotid artery was measured by ultrasound as a surrogate marker of atherosclerosis and vascular hypertrophy. In this population, the average annual progression of carotid IMT was 14  $\mu\text{m}$ . For each increase of 2.5  $\mu\text{g}/\text{m}^3$  in residential PM2.5 concentration, there was an additional 5  $\mu\text{m}$  increase annually in IMT progression. Furthermore, in the six metropolitan areas of the MESA, increased concentrations of PM2.5 and traffic-related air pollution were associated with progression in coronary artery calcification. Supporting these atherosclerotic changes, MESA data also demonstrated PM2.5 exposure was associated with reduced numbers of HDL-particles critical in maintaining cholesterol balance in the arterial wall.

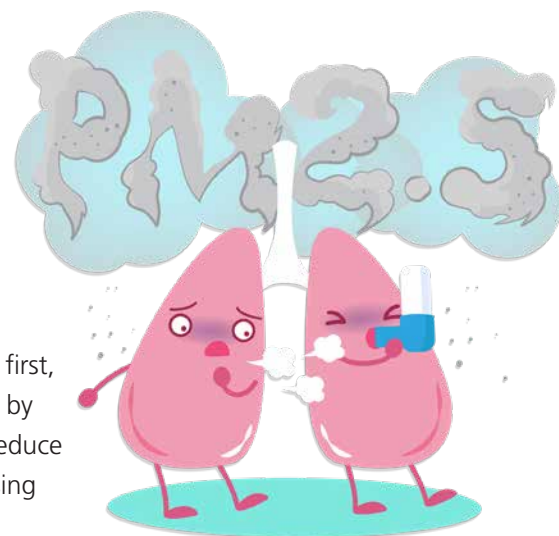
At the cellular and molecular level, the exposure to PM2.5 both directly and indirectly causes an inflammatory reaction and reduces anti-oxidative capability which would normally counteract reactive oxygen species (ROS). The increase in chronic inflammation and increased production of ROS pose risks in developing non-communicable diseases (NCDs)—for instance, type 2 diabetes mellitus and cardiovascular disease in long-run. Indeed, investigative reports<sup>4,5</sup> have shown circulatory antioxidants are exhausted in response to PM2.5 toxicity, which is an important mechanism in mediating pathophysiological and biochemical disorders.

### Can nutrients minimise some harmful effects of PM2.5?

There are ways to protect people from harmful effects of PM2.5: first, reduce PM2.5 emission to meet the air quality guidelines produced by WHO, which is the ultimate goal and foremost solution; second, reduce PM2.5 exposure when PM2.5 level is high, which includes minimising

### At the cellular and molecular level, the exposure to PM2.5

both directly and indirectly causes an **inflammatory reaction** and **reduces anti-oxidative** capability which would normally counteract reactive oxygen species (ROS).



outdoor activities, and using devices like air filters and special masks; third, reduce the harmful effects of PM2.5 exposure by taking clinically tested medicines; and fourth, supplement some nutrients that have also been shown to be effective in minimising the response to PM2.5 exposure. This latter approach is neither physical nor pharmaceutical, but nutritional.

In several clinical studies over the last 20 years, some nutritional ingredients have been specifically used to target some responses to PM2.5 exposure in humans.

### Vitamin A

A longitudinal investigation<sup>6</sup> in 493 non-smoking women with singleton pregnancies demonstrated an inverse association between PM2.5 exposure in pregnancy and birth outcomes. The negative effect of higher prenatal PM2.5 exposures (above third tertial) on birth weight and birth length were significant in women who had lower daily vitamin A intakes (<1,378 µg), but not in those with higher intakes (>1,378 µg).

### B Vitamins

B vitamins include folate, pyridoxine (vitamin B6), cyanocobalamin (B12) and methionine (which is an amino acid, but like other B vitamins creates a methyl group during metabolism). Intake status was found to modulate PM2.5-induced HRV in a normative ageing study<sup>7</sup> in elderly men. The increase of PM2.5 caused SDNN reduction: for each 10 µg/m<sup>3</sup> increase of PM2.5, the adjusted change in SDNN was -7.1 percent (p=0.03). Those who had lower dietary intake of vitamin B6 (<3.65 mg/d), B12 (<11.1 µg/d) and methionine (<1.88 mg/d) were accompanied by a pronounced reduction in SDNN. In contrast, a higher intake of vitamin B6 (≥3.65 mg/d), B12 (≥11.1 µg/d) and methionine (≥1.88 mg/d) abrogated HRV reduction. The folate intake did not prevent HRV from reduction statistically in this observational study.



## Vitamins E and C are potent antioxidants.

In a recent pilot human trial<sup>8</sup>, PM2.5 at 250 µg/m<sup>3</sup> induced methylation changes in genes involved in mitochondrial oxidative energy metabolism, was prevented by supplementation with a combination of B vitamins (2.5 mg/d folic acid, 50 mg/d vitamin B6, and 1 mg/d vitamin B12).

### Vitamins C and E

Vitamins E and C are potent antioxidants. In a Brazilian study<sup>9</sup> evaluating the effects of administering vitamins C and E on occupational and residential exposure to air pollution, a total of 80 human subjects were divided into four groups: non-exposed individuals as controls, residents (about 2 km from the plant), indirectly exposed (office workers located about 200 m from the plant) and directly exposed (working in the coal burning areas). In response to direct exposure to airborne contamination, glutathione (an important antioxidant capable of preventing damage to cellular components caused by heavy metals and ROS including free radicals, peroxides, and lipid peroxides) was reduced in the blood; thiobarbituric acid reactive substances (TBARS) and protein carbonyls



(PC) were increased in plasma, and the activities of superoxide dismutase (SOD) and catalase (CAT) were increased in red blood cells. Compared with the subjects not exposed to the pollution, glutathione S-transferase (GST) was increased in all three exposure groups, representing a persistent oxidative insult and inability to detoxify. Daily supplementation with a combination of vitamins C and E (500 mg and 800 mg respectively for 6 months) effectively normalised these unfavourable alterations. It should be pointed out the dietary nutrient intake profiles in all four groups were not different, but the  $\alpha$ -tocopherol concentrations that represent the circulating vitamin E level were reduced in those exposed directly and indirectly to contaminated air as well as those living in the nearby areas (by 51 percent, 36 percent and 37 percent respectively) compared with the control group. This phenomenon was indicative of the same vitamin E depletion previously found in human cigarette smokers.

Supplemental vitamin C at 500 mg daily<sup>10</sup> in pregnant smokers improved results of pulmonary function tests (PFTs) and decreased wheezing compared with those randomised to placebo through the first year of life for the child. Higher vitamin E and C intakes were associated with fewer asthmatic-related symptoms in children who were exposed to polluted atmospheric air (PM10, not PM2.5, was measured in the study).

### Vitamin D

Vitamin D deficiency is found in most areas and age groups worldwide, although its prevalence is much more severe in areas with air pollution than without. Ultraviolet B (UV-B) is needed for vitamin D synthesis in the skin, but PM2.5 smog diminishes the penetration of solar UV-B radiation to the earth's surface. Moreover, people may choose to stay indoors to avoid breathing dirty air. Air pollution constitutes another risk factor for vitamin D deficiency in addition to established ones.

### Omega-3

The effect of omega-3 long-chain polyunsaturated fatty acids on preventing PM2.5 associated HRV reduction was evaluated in a double-blind clinical trial<sup>11</sup>, in which a total of 50 subjects over 60 years old were randomised to receive 2 g/d of fish oil containing a combination of 52 percent docosahexaenoic acid (DHA) and 25 percent eicosapentaenoic acid (EPA) or placebo (2 g soybean oil) for six months (one month pre-supplementation + five months supplementation). During this time, the ambient PM2.5 levels varied from 5.1 to 49  $\mu\text{g}/\text{m}^3$ . The 24-hour average of PM2.5 concentration was  $18.6 \pm 8.0 \mu\text{g}/\text{m}^3$ . Before supplementation, each 8  $\mu\text{g}/\text{m}^3$  increase in PM2.5 (which was one standard deviation or SD) resulted in 27 percent reduction of SDNN—but in those with fish oil intervention, the reduction was only 0.5 percent.

Another double-blind study<sup>12</sup> tested the protective effects of fish oil against PM2.5-induced oxidative stress, in which 52 participants over 60 years old in nursing facility in Mexico City were randomly assigned to receive either fish oil (2 g/d containing 52 percent DHA and 25 percent EPA) or placebo for four months. During the study period, the mean ambient daily PM2.5 level was 38.7  $\mu\text{g}/\text{m}^3$  (ranging from 14.8 to 70.9  $\mu\text{g}/\text{m}^3$ ). Both groups spent about 93 percent of their time indoors, and the mean indoor and outdoor PM2.5 measurements were highly correlated ( $r=0.95$ ). The exposure to indoor PM2.5 decreased circulating levels of superoxide dismutase (SOD) and





glutathione in these subjects but supplementation with fish oil significantly elevated SOD and glutathione levels. Also, fish oil significantly decreased plasma lipoperoxidation (LPO) products, which damages cell membranes and is pro-mutagenic and pro-carcinogenic.

The inhalation of polluted air causes an increase in plasma triglycerides (TG) and very low-density lipoprotein (VLDL), which are pro-atherosclerotic and cardiovascular risk factors. Supplementation with fish oil prevented the rises of TG and VLDL in circulation.<sup>13</sup>

It should be reiterated that the ultimate goal of environmental protection against air pollution is to reduce pollutants including PM2.5, which are generated from various sources and emitted to the atmosphere. Long before this goal is realised, PM2.5 remains a significant threat to public health and wellbeing. Fortunately, some nutrients hold some promise in fending off the adverse effects of PM2.5. ●

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# Fortifying for the Future: How Staple Food Fortification Can Help Tackle Hidden Hunger Worldwide

by Sarah Louis

**S**hortages in adequate vitamin and mineral intake have led to a rising incidence of 'hidden hunger', a phenomenon where individuals have a chronic lack of essential micronutrients in their diet. Such deficiencies continue to plague populations across the globe, particularly in developing countries where people cannot afford—or do not have access to—nutritious food. However, the rise in calorie-rich—yet nutrient-poor—diets which fail to meet nutritional requirements means hidden hunger is also present in developed nations.

This issue was highlighted in 2015, when the United Nations adopted the 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals, which aim to end poverty, protect the planet and ensure prosperity for all by 2030. The second goal is 'Zero Hunger', which specifically addresses the need to end all forms of hunger and malnutrition across the globe. One method of achieving this, recognised by governments, non-governmental organisations and food manufacturers alike, is through staple food fortification.

## The impact of malnutrition

Inadequate nutrition can have a major, long-lasting impact on human physical health and development. For example, being deficient in vitamin A is a leading cause of blindness, and can contribute to high rates of childhood mortality and serious birth defects.<sup>1</sup> Meanwhile, vitamin D is well known for its role in calcium absorption and supporting both the immune system and cardiovascular health, with deficiencies potentially contributing to rickets in children and osteoporosis in adults.<sup>2,3</sup> Nutritional shortfalls are particularly dangerous in pregnant women and infants, with a lack of good nutrition increasing the risk of stunting and childhood mortality.<sup>4</sup> In particular, severe folic acid deficiencies in pregnant women can cause anaemia and result in premature birth.<sup>5,6</sup> Ensuring adequate nutrition in the early years of life is essential for giving an individual the best chance of good health as he or she gets older.

Hidden hunger can also be detrimental to local economies, as individuals with malnutrition-related ill health are often unable to work, which can cause lowered productivity for businesses and increased healthcare costs. In Africa and Asia, for example, the economic costs from lost productivity and economic growth as a result of malnutrition are as high as 11 percent of gross domestic product (GDP) annually.<sup>7</sup> With this in mind, it is clear governments and health organisations have a multitude of reasons to find a solution to this worldwide issue.

## Managing hidden hunger with staple food fortification

While a healthy and balanced diet is always recommended as the preferred way to improve a person's nutritional status, in some cases this is simply not possible. So, what can be done?







There are a range of methods that can be considered to tackle global malnutrition—from government initiatives to subsidising the cost of food to increasing awareness and education—but one of the most effective strategies is fortification.

Fortification is a safe, affordable and proven tool to enhance the nutritional value of food products. This process involves adding or replacing essential vitamins and minerals that may have been lost during processing, and has become well recognised for its benefits to public health. For fortification programs, the vehicle (food) selected to be fortified is of upmost importance to the program's success. Fortifying foods that are most commonly consumed, such as staples like flour and rice, helps to maximize the impact and is, in fact, now mandatory in many countries. Staple food fortification began in the 1970s and the Middle East was one of the earliest regions to adopt the practice, with Saudi Arabia implementing wheat flour fortification in 1978.<sup>8</sup>

Nowadays, the fortification of staple food is a widely accepted method of improving public health, supported by a range of scientific studies and success stories. In Cameroon, for example, a 2009 national survey found micronutrient deficiencies in its residents were a major public health concern. In response, a mandatory food fortification program was launched nationwide in 2011 which saw wheat flour fortified with micronutrients. In 2017, a follow up study revealed a noticeable improvement in the micronutrient status of women and children, as well as a decrease in the prevalence of maternal anaemia.<sup>9</sup>

While there are a range of staple foods that can be fortified—from vegetable oil to sugar—flour and rice are particularly effective as they constitute a core part of the diet in many developing and developed countries.

## Fighting back with flour fortification

Flour, primarily from wheat and maize, is one of the world's most widely distributed and consumed staple food products. Over 600 million metric tons of wheat and maize flours are milled each year, which are then used to produce popular foods including noodles, breads, pasta, and other flour products across the globe.<sup>10</sup> This means there is huge potential for flour products to improve public health when fortified with a wide range of micronutrients. This opportunity has been recognised by governments worldwide, with flour fortification mandatory in 87 different countries.





These populations are now receiving a nutritional boost when consuming a wide range of commonly eaten food items.

When fortifying flour, there are a number of different vitamins and minerals that can be added, meaning the varying health needs of target populations can be specifically addressed. Micronutrients can be incorporated singly or as a premix to flour; it is vital the flour is well mixed so the added nutrients are distributed uniformly throughout the product. This is achieved by adding the vitamins and minerals at a rate compatible with the flow of flour along a conveyor belt, using adjustable feeders, or introducing the micronutrients when flours from different batches converge. It is important to ensure the particle size and weight of these micronutrients are the same as—or similar to—that of the flour product.

### The rise in rice fortification

Rice is one of the most commonly consumed foods in the world, providing more than 20 percent of the world's calorie intake—with approximately 480 million metric tons of rice produced annually.<sup>11</sup> As a staple food for over half of the global population, rice offers a good and affordable source of energy. However, white rice does not provide significant levels of most micronutrients (when measured against the daily recommended intakes) and the milling process to produce it also removes both the fat and nutrient-rich bran layers. Therefore, fortification is ideal for replacing the nutrients lost during this process and improving public health.



**There are hundreds of varieties of rice available** in the market, any of which can be fortified to suit the tastes and habits of different populations.

While flour fortification has been around for decades, efforts to fortify rice are relatively new, with just 1 percent of industrially-milled rice kernels on the market currently fortified.<sup>12</sup> Yet, with a growing pool of scientific evidence substantiating the effects of rice fortification and increased support from governments and non-governmental organisations alike, the proportion of rice being fortified is expected to rise significantly in coming years.

There are hundreds of varieties of rice available in the market, any of which can be fortified to suit the tastes and habits of different populations. There is also a range of methods to fortify rice, including dusting, coating and hot extrusion. While all methods are more effective at improving public health than no fortification at all, there are key production considerations for each. Dusting, for example, relies on an electrostatic force to bind the dry powder to the



surface of the grain, which runs the risk of the micronutrients being lost if rice is cooked in too much water, or washed before cooking. Similarly, the coating method uses a wax or gum to 'fix' the micronutrient layer that is sprayed on to the rice, which can also be lost if the kernels are not 'rinse-resistant'. Hot extrusion fortification technology, on the other hand, has been specifically developed as a robust and stable method of increasing the nutritional value of rice without a change in consumer behaviour. In this process, broken rice grains are ground into flour and mixed with water and nutrients to produce a rice dough. The fortified dough is then passed through an extruder to produce fortified kernels which are then blended with standard rice. The fortified kernels look and taste like non-fortified rice, but the vitamins and minerals cannot be washed off, meaning consumers will get the nutrition they need.

### What makes staple food fortification work?

Knowing how fortification works is important, but understanding why it works is key to widespread adoption. One of the main benefits of staple food fortification is the high return on investment. Manufacturers and governments can quickly see tangible results to justify the initial spend. By improving the nutritional status and public health of an entire country, millions could be saved on healthcare costs each year, and more people could work and, therefore, contribute to the economy. In fact, for every €1 spent on fortification, it is estimated €25 of improvements in health and future earnings are made.<sup>13</sup>

Another critical reason why fortification has such a hugely positive impact is due to its acceptability. Fortification of the food products that are most affordable, commonly consumed and accessible enables individuals to get the nutrients they need without changing their dietary habits. Similarly, advances in fortification technology mean it is possible to fortify food without negatively changing the appearance, taste, smell or texture of it, and the fortified foods can even be prepared and cooked in the exact same way as non-fortified foods. By eliminating the need for any additional education or a change in consumers' behaviour, fortification can be seamlessly integrated into daily lives. In many programs aiming to help improve public health, consumer attitudes and usage habits can be difficult hurdles to overcome, so ensuring people can continue with the same behaviour day-to-day, while increasing their levels of nutrition,

plays a large role in fortification successes. This is of particular importance in developing countries where food choices are limited and requiring active consumer engagement could lead to difficulties.

## Planning future programs

When engaging in staple food fortification, there are a number of considerations. From local legislation to dietary preferences, understanding the market is critical to a successful program. Particularly in developing countries, where access to nutritious food is sparse, fortification is saving lives by reducing micronutrient deficiencies. Therefore, it is essential the vitamins and minerals remain stable in the food product to ensure that deficiencies are being addressed as intended. This can be affected by several issues, from the quality of the micronutrients to how the products are stored. Poor quality vitamins can also negatively impact the taste and appearance of fortified products, reducing customer acceptance. Partnering with companies with a long history in fortification to benefit from their knowledge and expertise is vital for millers and brand owners looking to improve public health as part of such programs.

Hidden hunger continues to be a major public health concern across the globe, with devastating long-term impacts on the wellbeing and development of individuals, societies and nations worldwide. Staple food fortification is a proven method of getting key micronutrients to those in need safely and effectively and can be tailored to meet the specific requirements and preferences of particular populations. However, it is vital that programs are planned and delivered with quality in mind for maximum improvement on human health. ●

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# Takeaways for Your Business

**The idea that you** can get all your nutrients from food is fine in theory, and is a common argument used by supplementation detractors. There is evidence to suggest consuming nutrients from food is more beneficial than supplements, but there are many reasons why diet alone is insufficient. Modern diets increasingly provide lower levels of necessary micronutrients, leading to chronic deficiencies in developed nations—this is matched by the deficiencies seen in developing countries where the population may not have access to nutritious food.

At the same time, industry certainly should not encourage supplementation as a panacea to a poor diet and encouraging consumers to supplement effectively is all down to communication. This can be seen in the high acceptance levels for maternal supplementation: according to a study from DSM, around 80 percent of pregnant women in Europe take a supplement while pregnant, and in China 98 percent of expectant mothers use maternal health products. Many women are adding folate and B vitamins and omega-3s to their regimes to best support their pregnancy. This can all be attributed to effective communication. Other categories can also benefit from improved consumer communication.

Without resorting to scare tactics and threatening poor health if consumers avoid supplements, focus on explaining the oft-overlooked reasons for adding natural products to diets. Air pollution is particularly concerning and with plenty of commonly-supplemented nutrients potentially minimising the harm from particulate matter, highlighting these effects could encourage consumers to continue supplementing. Long-term adherence to a supplementation regime is always the goal and there is real power in effective communication to improve the odds of a consumer sticking to their program.

Air pollution is a complementary issue to another sustainability concern. Research shows modern farming techniques used to increase yield deplete the soil of essential nutrients, while changes to carbon dioxide levels from climate change are leading to a reduction in nutrient density in rice—a staple food for much of the world's population. As your company incorporates sustainability into its business practices—evidence shows consumers are increasingly invested in mission-driven companies—communicating your understanding of this issue and the solution supplementation offers is a key way to drive sales.

Confronted with the argument that dietary supplements do little more than make their urine extremely expensive, consumers will always question the need to supplement. Accurate, easily-digestible and evidence-backed information will help consumers identify where they can be helping themselves to optimal health; and understanding the sustainability concerns around nutrient depletion will mean industry can bring more health to more people worldwide. ●

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