

Nutrition Trends & Insights: An Analysis of Mango Nutrition Attributes Within the Context of Current Trends

National Mango Board

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Overview

The National Mango Board (NMB) invests considerable resources in nutrition research with the goal of better understanding the compounds found in mangos and how they impact various conditions in the human body. The results of this research directly feed the marketing efforts of the NMB, fueling communications opportunities and developing the nutrition brand image of the mango fruit.

The goal of this report is to examine the predominant nutrition attributes of mangos within the context of current consumer and research trends, generating intelligence to help inform the NMB's nutrition research strategy.

Methodology

Salt & Co. determined the predominant nutrition attributes (nutrients, compounds, or characteristics with the greatest potential for future research) of fresh mangos by examining the NMB's existing nutrition data and selecting those attributes with the greatest concentration in fresh mangos. These attributes include vitamin C, beta carotene (vitamin A), folate, fiber, vitamin B6, and polyphenols.

Although mangos are a good source of the mineral copper, this nutrient was not included as one of the priority nutrition attributes because our research indicated that copper has low consumer awareness, does not appear to be contributing to any significant health trends, and does not appear to be a primary interest in terms of current nutrition research. This aligns with results from the NMB's 2013 Usage and Barriers Survey, which noted that respondents found copper to be "unfamiliar in the context of food" and that it "tends to be a turn-off as a nutritional claim."

After determining the predominant nutrition attributes, Salt & Co. gathered consumer trends data from a variety of sources including third party consumer research as well as news and keyword search analysis. In addition, we identified research trends pertaining to these attributes by conducting a high level review of existing published research (non-mango specific) and gathering input from other nutrition science experts.



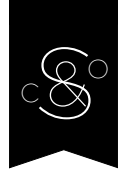
Food & Health: What's Trending with Consumers?

There's no question that today's consumers value foods for their potential health benefits, and this is only growing in importance. In fact, recent data from the International Food Information Council's (IFIC) 2014 Food & Health Survey found that more than nine out of ten consumers have given at least "a little" thought to the healthfulness of their foods and beverages, and half of consumers have given "a lot." Seventy-one percent (71%) of consumers reported that health influenced their food and beverage selection—a 15 percent jump since 2010. This survey found the impact of healthfulness increased across all ages, ethnicities, education, and socioeconomic demographic groups with the greatest rise among younger consumers and men.

Increasingly, consumers expect their food choices to protect them from chronic diseases or specific conditions. The 2012 Gallup Study of Nutrient Knowledge & Consumption found that eight in ten consumers believe that functional foods can help prevent or delay the onset of heart disease, hypertension, osteoporosis, and type 2 diabetes. And six in ten associate functional foods with benefits linked to age-related memory loss, cancer, and Alzheimer's disease. According to Experian/Packaged Facts Spring 2013 Consumer Survey, 56% of consumers bought foods or beverages that targeted a specific condition. Twenty-nine percent (29%) of consumers purchased cholesterol-lowering foods/drinks, and 24% purchased products targeting weight control. Other condition-specific benefits sought out by consumers include blood pressure (20%), digestive health (17%), heart/circulatory (14%), diabetes (13%), and bone/joint (11%).

Based on our research, the following conditions are trending highest in terms of their influence on consumer food choices:

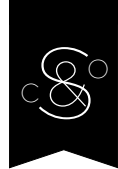
- **Heart Health:** Consumers are looking for cholesterol-lowering and blood pressure benefits most often, but emerging heart-related concerns include circulation, stroke, and plaque formation.
- **Weight Management/Blood Sugar:** There is also a good bit of overlap between concerns regarding weight management and diabetes since these two conditions are closely intertwined, and controlling blood sugar and insulin levels is believed to be an important part of both weight and diabetes management.
- **Digestive Health:** Consumers continue to have a strong interest in digestive health, especially as research is finding associations between gut health and other conditions, such as obesity, inflammation, and immune function. According to the Hartman Group, lower gastrointestinal issues are gaining prominence with digestive regularity becoming more important to consumers.
- **Aging:** A number of health conditions related to aging are of concern to consumers, including maintenance of energy levels, mental acuity, bone health, eye health, and cancer.



We are also seeing emerging opportunities for foods that offer benefits in the following areas:

- **Satiety:** Foods that naturally increase feelings of satiety (or, fullness) and help prevent hunger and overeating will become important. This is closely tied to concerns for weight management but overlaps with concerns for blood sugar control and diabetes.
- **Skin Health:** According to Datamonitor, consumer familiarity with the benefits of fruit and vegetable consumption is extending to beauty innovation (such as use of “superfruits” as ingredients in skincare products). There appears to be a growing interest in the relationship between diet and skin health, a topic frequently covered by consumer media. This has long been the subject of debate, however in recent years we have seen an uptick in research investigating the role of diet and skin health.

An important macro-trend with consumers as well as nutrition research is to focus on the health effects of consuming the whole food as opposed to isolated nutrients or extracted compounds from the food. There is research to indicate that consuming nutrients in isolation above and beyond established daily recommendations may have unintended consequences, such as increased risks of certain cancers, impaired nutrient balance, etc.



Predominate Mango Nutrition Attributes

The following nutrition attributes of fresh mangos are the focal points of this report: vitamin C, beta carotene/vitamin A, folate, fiber, vitamin B6, and polyphenols (Table 1). These attributes were selected because they have well-documented functions in the human body; are found in the flesh of fresh mangos in concentrations deemed to be of significance to human health; and most have emerging health benefits demonstrated by third-party research.

Regarding beta carotene and vitamin A, as noted in Table 1, mangos contain the vitamin A precursor beta carotene. Often, the relationship between beta carotene and vitamin A is misrepresented by consumer literature, and is thus misunderstood by the majority of consumers. As such, we discuss trends related to both beta carotene and vitamin A throughout this report since the two are related within the context of mango nutrition.

Table 1: Mango’s Predominant Nutrition Attributes

Nutrition Attribute	Amount Contained in 1 Cup of Fresh Mango	Function
Vitamin C	60 mg (100% Daily Value)	Vitamin C is an antioxidant with numerous functions in the human body, including supporting healthy cognitive and neurologic function, collagen formation, and wound healing. In addition, it plays an important role in immune function, keeping gums and teeth healthy, and increasing the absorption of non-heme iron.
Beta Carotene/Vitamin A	1785 IU (35% Daily Value)	Vitamin A in mango occurs in the form of beta carotene, an antioxidant pigment which the body converts to vitamin A. Beta carotene is often referred to as a “vitamin A precursor” or “provitamin A”. Vitamin A is critical for vision and plays an important role in immune function, reproductive health, bone growth, and the maintenance of healthy skin.



Nutrition Attribute	Amount Contained in 1 Cup of Fresh Mango	Function
Folate	71 ug (35% Daily Value)	Folate is a B vitamin which helps the body make red blood cells and DNA, supports healthy cardiovascular function, and helps reduce a woman's risk of neural tube defects during pregnancy.
Fiber	3 g (12% Daily Value)	Fiber aids in digestion, helps control constipation, slows the absorption of sugar into the bloodstream, and can increase feelings of satiety after eating.
Vitamin B6	.2 mg (10% Daily Value)	Vitamin B6 is involved in immune function, plays an important role in cognitive development, helps the body maintain normal blood sugar levels, helps the body make hemoglobin, and helps maintain normal nerve function.
Polyphenols	236-1395 mg/kg GAE (Gallic Acid Equivalent), no Daily Value established (Perkins, et al 2009)	Polyphenols are a large and diverse class of phytochemicals with various antioxidant and anti-inflammatory properties.

Mango Nutrition: What is Trending with Consumers?

The predominant nutrition attributes of mango are very relevant to consumers, as confirmed through third party consumer research reports and web search data.

- Consumer Research
- Consumer research indicates that several nutrition attributes are important to consumers, especially fiber, vitamin C, B vitamins (mango contains two B vitamins: folate and vitamin B6), vitamin A/beta carotene, and polyphenols, specifically:
- According to the 2012 Gallup Study of Nutrient Knowledge & Consumption, 40% of consumers say they are making a strong effort to get more vitamin C, with 34% reporting the same for B vitamins, and 24% for vitamin A.

- Fifty-three percent (53%) of consumers are seeking more fiber (2014 International Food Information Council Food & Health Survey). Sales of foods with a fiber health claim totaled \$8 billion in 2013 (Nielsen).
- Carotenoids (such as beta carotene) have joined polyphenols as mass market phytochemical opportunities (Sloan, A.E. 2014. TrendSense™ predictive model report. Sloan Trends Inc., Escondido, Calif. www.sloantrend.com).
- The NMB's 2013 Mango Usage and Barriers research found that respondents seem most impressed by knowing fiber and folate are in mangos and that vitamins C, A, and B6 are nice to know for mangos as well.

Media Coverage of Predominant Nutrition Attributes and Health

Salt & Co. examined media coverage of the priority nutrition attributes to determine general associations with specific health concerns/conditions (Table 2). Although we recognize that the association of a nutrition attribute with a health condition in the media does not mean there is a scientifically valid association, this exercise gives us a glimpse into how popular culture views mango's predominant nutrition attributes, which helps us better understand the trends at play.

TABLE 2: Health Conditions Associated with Mango's Predominant Nutrition Attributes in the Media

Predominant Nutrition Attribute	Health Conditions Associated Within the Media
Vitamin C	Skin health, endurance exercise recovery, cold fighting, immune health, cholesterol lowering
Beta Carotene/Vitamin A	Skin health, aging, vision
Folate	Birth defect prevention, Alzheimer's, cancer
Fiber	Beneficial bacteria in the gut, heart health, weight management, cholesterol lowering
Vitamin B6	Neurotransmitters (serotonin, melatonin, dopamine), increased blood flow
Polyphenols	Glucose metabolism, anti-inflammatory, anti-aging/longevity

Mango Nutrition: What is Trending in Health Research?

Salt & Co. conducted a high level review of research studies pertaining to predominate nutrition attributes and health that have been published in peer-reviewed scientific journals over the last five years (Table 3). In doing so, we've gained considerable insight and perspective on both the volume of published research as well as trends within this research. This research was not mango-specific, however, and mostly examined each nutrition attribute in isolation. It is important to note that we did not evaluate study design as part of this exercise as this was not critical to our intended goal of identifying trends and gaining a better understanding of where the scientific community is placing emphasis with regards to these nutrition attributes.

Many of mango's predominant nutrition attributes are well-established in terms of their function within the human body, namely, the vitamins and minerals found in mango. However, nutrition is an evolving science and research continues to uncover potential benefits and mechanisms of action of these highly-recognized micronutrients. Polyphenols, on the other hand, could still be considered "emerging" beneficial compounds as the body of research, although robust, is still in the early stages. Based on our review, research regarding mango's predominant nutrition attributes appears to be clustering in the following areas:

- Vitamin C

Vitamin C has many well-established health benefits, however there are a few areas where recent research appeared concentrated, including:

- » Circulatory benefits
- » Role in glucose metabolism
- » Bone health
- » Immune support

- Beta Carotene/Vitamin A

Beta carotene and vitamin A are specific, distinguishable compounds, however they are interrelated since beta carotene serves as a precursor for vitamin A. Most of the vitamin A research focused on consequences of deficiency in developing countries and strategies to address. Because beta carotene is the form found in mango, it makes sense to pay greater attention to this research, specifically.

- » Beta carotene relationship with cancer (there is conflicting evidence here)
- » Beta carotene potential for cardiovascular protection (due to beta carotene's antioxidant activity)

- Folate

Folate has many well-established benefits during pregnancy, and these benefits and the mechanisms involved are still the subject of much research. However, there are several additional areas of research into folate's potential benefits, including:

- » Cancer protection (research addresses a variety of cancer types)
- » Cognitive health (protection against age-related memory loss, depression, etc.)
- » Cardiovascular benefits

- Fiber

There are many well-documented health benefits of fiber, however fiber research continues to grow with new research into specific types of fiber and the role of these fibers on gut microbiota. In addition, there is still much fiber research underway regarding various chronic diseases, including:

- » Cancer protection (research addresses a variety of cancer types)
- » Obesity protection
- » Cardiovascular benefits
- » Prebiotic fibers and gut health/microbiome effects
- » Inflammation
- » Immune health
- »

- Vitamin B6

Only a few studies of significance were identified for vitamin B6, and these addressed the following areas:

- » Colorectal cancer survival
- » Association with depressive symptoms in elderly
- » Protection against active disease in Lupus patients
- » Cardiovascular disease protection (this study specifically looked at B6 from supplements, not food)

- Polyphenols

The field of polyphenol research is literally exploding. As mentioned in Table 1, this is a large and very diverse class of phytochemicals, and the research spans the spectrum of basic science to human clinical trials. Over the past five years, there was notable polyphenol research published for several types of food including green tea, cocoa, berries, tree nuts, olives, olive oil, grapes, soybeans, cranberries, and coffee. The following general areas appear to be where most of the polyphenol research has focused:

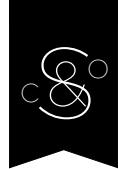
- » Relationship between polyphenol and fiber digestion/metabolism
- » Effect on gut microbiome
- » Immune function
- » Absorption and metabolism of polyphenols
- » Gene interactions of polyphenols
- » Neuroprotective effects
- » Cardioprotective effects
- » Skin protection (this is an emerging area)

Analysis & Recommendations

Based on our review of consumer and research trends, Salt & Co. believes there are numerous opportunities to further develop the NMB's nutrition research pipeline to generate results that will support on-trend marketing messages. Specifically, the NMB should consider the following directions for future nutrition research:

Composition, Bioavailability, and Mechanistic Studies

This research will further elucidate mango's nutrition attribute composition, bioavailability, and mechanisms of action.



- **Fiber**

Composition studies to determine fiber make-up of mangos, including presence of prebiotics

- **Polyphenols**

- » Composition studies measuring content of various polyphenols in one serving of mango (this data may exist, need to verify with current mango researchers)
 - Example: the amount of mangiferin (or any other polyphenol found in mango) is found in a 100 grams of fresh mango
- » Mechanistic studies
 - Example: the mechanisms by which polyphenols exert specific effects within the human body)
- » Bioavailability, including brain bioavailability
 - Example: are polyphenols or their metabolites absorbed into the blood stream from the gut and do they cross the blood-brain barrier)
- » Microbiome impact of mango polyphenols
 - Example: how do mango polyphenols affect bacterial environment in the gut
- » Impact on fat absorption and energy expenditure
 - Example: do mango polyphenols impact the amount and types of fat absorbed into the blood stream

Health Impact Studies

This research will specifically investigate the role of mango consumption of various health endpoints.

- **Digestive Health**

- » Microbiome impact of mango consumption, including analysis of colonic metabolism of mango fibers and polyphenols
- » Impact of mango consumption on indices of gut health other than microbiome, such as regularity, inflammation, etc.

- **Inflammatory Response**

- » Impact of mango consumption on various indices of inflammation

- **Immune Function**

- » Impact of mango consumption on various indices of immune function

- **Heart Health**

- » Impact of mango consumption on various indices of cardiovascular health, such as lipid profile, blood pressure, circulation/blood flow, etc.

- **Weight Management/Blood Sugar**

- » Research from Dr. Edralin Lucas at Oklahoma State University has already demonstrated the potential blood sugar benefit of mango consumption in obese. This

research should be replicated and further explored.

- » Impact of mango consumption on insulin levels
- **Aging**
 - » Impact of mango consumption on various indices of cognitive health, including neuro-protective effects of mango polyphenols
 - » Impact of mango consumption on self-reported indices of “energy level”
 - » Continued research into impact of mango consumption on various types of cancers
- **Satiety**
 - » Impact of mango consumption on self-reported measures of satiety
 - » Impact of mango consumption on levels of hormone and/or neurotransmitters associated with satiety
- **Skin Health**
 - » Because mangos contain multiple nutrients with potential skin-health benefits and one animal study has been conducted with positive results, research investigating the skin health impact of mango consumption should be explored, including appropriate human trials.

Special Population Studies

- **Children and Adolescents**
 - » Impact of mango consumption on many of the aforementioned health impacts, such as blood sugar, weight management, immune function, etc.
- **Pregnancy**
 - » Impact of mango consumption on maternal folate status
 - » Impact of mango consumption during pregnancy and nutritional status of newborn
- **Athletes**
 - » Impact of mango consumption pre/post-event on indices of inflammation, muscle recovery, etc.

Prioritizing these research opportunities based on available budget is obviously a critical consideration. Salt & Co. recommends that the NMB fund composition, bioavailability, and mechanistic studies as soon as possible as these generate important baseline understandings which are critical not only for future research studies but also for nutrition message approval by the United States Department of Agriculture (USDA). These studies can be conducted concurrently with health impact studies.

The NMB’s nutrition research program is at a point where it is time to consider additional areas of health impact that have not been explored with regards to mango consumption. Digestive health and heart health should be considered new priority health areas, and research studies investigating these health areas may also be able to address impact on inflammatory and immune markers as part of the study design. Additional research attempting to validate the potential blood sugar benefits of mango consumption should also be consid-



ered sooner rather than later since this pilot research was recently accepted for publication. This research could also be expanded and built upon to further explore potential weight management benefits of mango consumption. The opportunity to research potential skin health benefits should be further explored with experts in dermatology as this is an emerging area of consumer interest. And because it does not appear to be an area where other commodity organizations are placing an emphasis, it could potentially provide a competitive advantage for mangos if positive associations were identified.

Appendix A: Research Associated with Mango's Predominate Nutrition Attributes (2009 to present)

Vitamin C

- » Benefits to endothelial function
- » Higher levels of vitamin C needed by diabetics
- » Consumption of vitamin C to improve exercise-induced bronchoconstriction
- » Benefits to muscle damage recovery in athletes
- » Association with fatigue, heart rate, and perception of exertion after exercise in obese individuals
- » Synergistic relationship with folate
- » Association with decreased post-prandial oxidative stress in diabetes
- » Decrease in cold symptoms when combined with zinc supplement
- » Potential glycemic control benefits
- » Compromised vitamin C status in diabetic smokers
- » Deficiency and alterations in physical and mental growth and immune health in children
- » Role in bone health

Beta Carotene/Vitamin A

- » Beta carotene associated with improved bone health while high intake of vitamin A associated with fractures and osteoporosis
- » Beta carotene supplementation associated with decreased oxidative stress
- » Beta carotene deficiency associated with certain cancers
- » Increased serum beta carotene in Mediterranean Diet
- » Low serum beta carotene associated with congestive heart failure, cardiovascular disease, and total mortality (emphasis in obese)
- » High serum beta carotene associated with increased risk of prostate cancer
- » Beta carotene consumption during pregnancy and carotenoid status of newborns
- » Dietary supplementation with plant sources of beta carotene as strategy for addressing vitamin A deficiency
- » Vitamin A consumption associated with delayed onset/prevention of amyotrophic lateral sclerosis (ALS)
- » Issues related to vitamin A deficiency in developing countries



- » Strategies to address vitamin A deficiency in developing countries
- » Vitamin A supplementation and positive/negative association with a variety of issues (cystic fibrosis, tuberculosis, bone health, iron deficiency, mortality risk, post operative oxidative stress, hypothyroidism, hyperuricemia)

Folate

- » Low serum folate associated with antenatal depression
- » Smoking during pregnancy associated with low serum folate levels
- » Folate supplementation during pregnancy associated with lower risk of stillbirth
- » Increased dietary folate may decrease breast cancer risk, especially among smokers
- » Low plasma folate status associated with decreased cognitive performance in elderly
- » High folate levels and prostate cancer risk
- » Many studies looking at cancer relationship and potential mechanisms (colorectal, breast, and other cancers)
- » Folate deficiency exacerbates cardiovascular risk by augmenting inflammation
- » Higher folate status associated with improved cognitive test scores in children and adolescents
- » Benefits of folate supplementation during pregnancy
- » Folate supplementation to help with iron deficiency anemia in adolescent girls
- » Folate and prevention of depressive symptoms
- » Folate status during pregnancy and risk of childhood leukemia in offspring

Fiber

- » Fiber intake associated with decreased risk of breast cancer
- » Fiber intake associated with decreased risk of kidney stones
- » Fiber intake not associated with arterial stiffness and inflammation in type-1 diabetes
- » Prebiotic fiber intake associated with decreased risk of metabolic syndrome
- » Fiber intake inversely associated with prostate cancer risk
- » Fiber intake influences gut microbiota and decreases risk of lung allergy symptoms
- » Fiber intake associated with lower cardiovascular disease risk
- » Fiber intake associated with decreased kidney cancer risk
- » Increased fiber intake associated with decreased risk of stroke
- » Mangos contain prebiotic fiber (unpublished research out of India)
- » Prebiotic fibers associated with health benefits
- » Fiber intake associated with decreased inflammation in the gut
- » Increased fiber intake associated with risk of zinc deficiency
- » Fiber intake can improve gut bacteria profile
- » Fiber intake made modulate immune response
- » High fiber associated with decreased inflammation and all-cause mortality in chronic kidney disease
- » Fiber intake may protect against obesity, constipation, and diabetes in children
- » Fiber assists in the transport of antioxidants (primarily polyphenols) through intestinal tract
- » Higher intakes of fiber and B6 may prevent active disease in lupus patients

Vitamin B6

- » Serum B6 and protection against oxidative DNA damage
- » Higher serum levels of B6 not associated with improved colorectal cancer survival
- » B6 deficiency common in nursing home environment
- » Marginal B6 status associated with depressive symptoms in elderly
- » Higher intakes of B6 and fiber may prevent active disease in lupus patients
- » B6 intake from dietary supplements associated with decreased heart disease risk

Polyphenols

- » Intake from plant sources can improve gut bacteria profile
- » Polyphenols transported by fiber through small intestine
- » Polyphenols can decrease fat accumulation in liver disease
- » Role of polyphenols in modulating immune system
- » Tea polyphenols associated with increased energy expenditure
- » Cardioprotective and anti-inflammatory effects of cocoa polyphenols
- » Role of polyphenols in reproductive health in obese women
- » Potential for polyphenol consumption to modify gene expression
- » Grape polyphenols as possible prevention/treatment for cognitive diseases including Alzheimer's
- » Cocoa polyphenols may decrease obesity-related disorders leading to decreased inflammation
- » Extensive mechanistic studies investigating green tea and cocoa polyphenols
- » Cranberry polyphenols increase activity of immune cells which may decrease cold and flu symptoms
- » Polyphenols in brassica species identified
- » Role of polyphenols in modulating gut microbiota
- » Green tea polyphenols protect against inflammatory bowel disease issues
- » Green tea, cocoa, and citrus polyphenol mechanisms for improving metabolic and cardiovascular issues
- » Higher intakes of flavonoids associated with decreased risk of metabolic syndrome
- » Health effects of olive oil polyphenols
- » Neuroprotective effects of olive polyphenols
- » Apple polyphenol gastrointestinal absorption and metabolism
- » Absorption and metabolism of pistachio polyphenols
- » Colonic metabolism of polyphenols from green tea, coffee and hazelnut skin
- » Plant polyphenol impact on gut microbiome
- » Green tea polyphenol protective effect on lipid profile, inflammation, antioxidant capacity
- » Polyphenols as important compounds in emerging field of nutraceuticals to promote skin health
- » Tea polyphenols and cancer protection
- » Mechanisms for neuroprotective effects of polyphenols
- » Anti-allerg effects of polyphenols
- » Neuroprotective effects of blueberry polyphenols
- » Soybean and green tea polyphenols improve immune function
- » Colonic metabolism of berry polyphenols
- » Brain bioavailability of grape polyphenols and neurologic protection
- » Role of polyphenols in energy metabolism
- » Cardioprotective effects of green tea polyphenols
- » Polyphenol effect on gene expression and relationship to cardiovascular health
- » Polyphenol impact on carbohydrate metabolism
- » Inhibition of platelet aggregation by polyphenols
- » Neuroprotective effects of green tea polyphenols
- » Consumption of nuts increases plasma polyphenol concentration

VITAMIN C

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BETA CAROTENE

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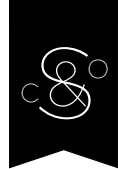
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