VITAMIN A MAIZE

THE FUTURE IS ORANGE

A food that can change your business
and the world naturally

HarvestPlus
Better Crops • Better Nutrition

HarvestPlus: Leading a global movement to deliver more-nutritious crops

Thanks to an innovative, non-GM approach to the time-honored process of natural crop breeding, maize (corn) can now be enriched with Vitamin A, turning a common staple food into a ready source of an essential nutrient for maintaining good health.

HarvestPlus leads and coordinates a global effort within the CGIAR global agricultural research network to improve the nutrition of staple crops. The CGIAR's unrivaled mix of knowledge, skills and research facilities means it is capable of responding to emerging development issues. For maize product development, The International Maize and Wheat Improvement Center (CIMMYT) and the International Institute of Tropical Agriculture (IITA) are at the core of a broad HarvestPlus alliance comprising CGIAR partners, National Agricultural Research Systems (NARS), and private seed companies.

HarvestPlus works with leaders in crop development and agriculture to unlock genetic variation in maize to develop Vitamin A maize. We use conventional breeding techniques to develop Vitamin A maize that can provide malnourished population groups with up to 50 percent of their daily Vitamin A needs; commonly grown varieties contain very small amounts of Vitamin A.

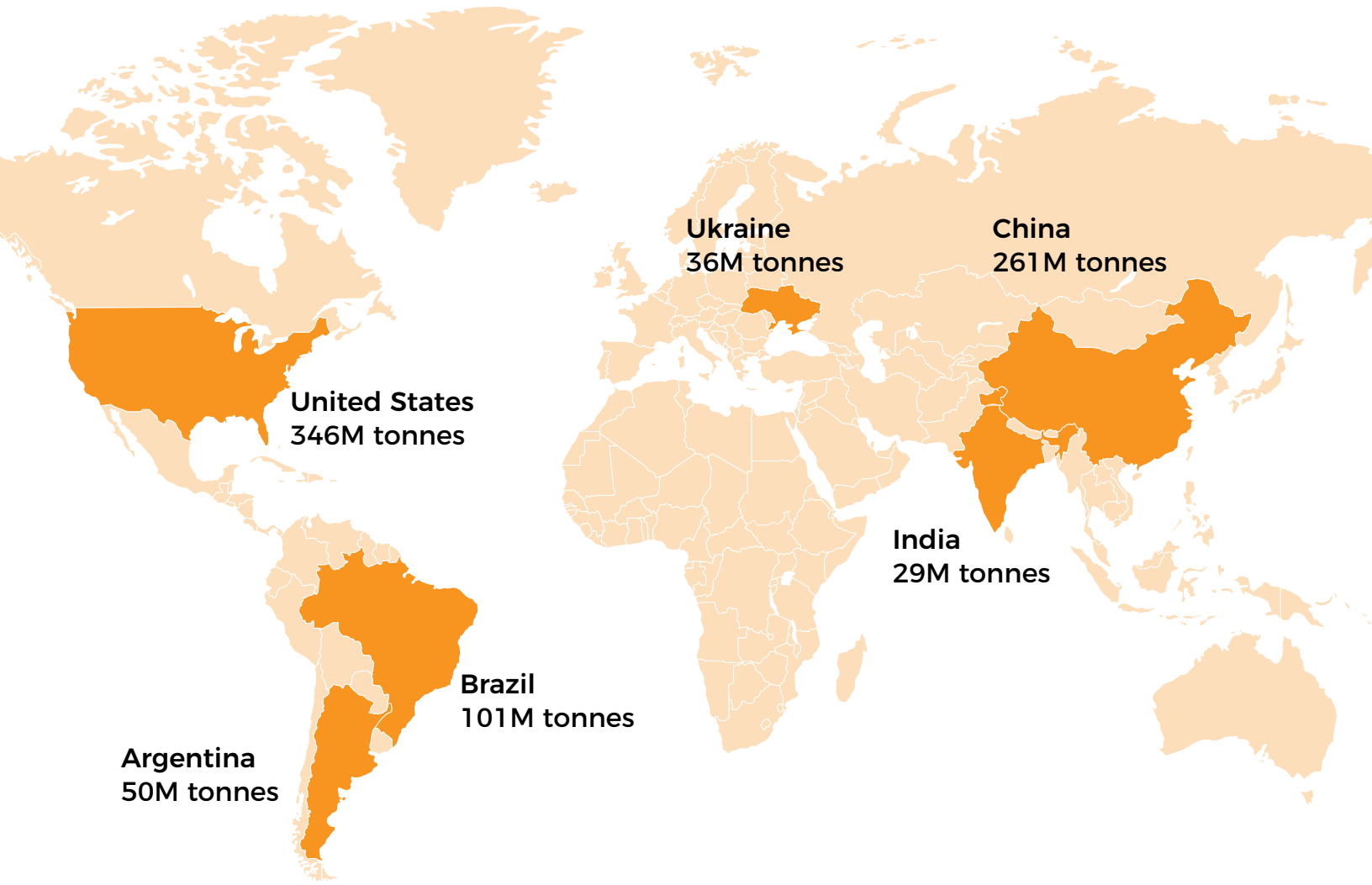
HarvestPlus, the global leader for developing and disseminating nutrient-enriched varieties of crops, works with partners to integrate Vitamin A maize (VAM) into local food systems. VAM is now a proven and effective intervention to address micronutrient deficiencies.

Carrots used to be white or purple, but now they are predominantly orange and are a major source of Vitamin A for millions of people. Our vision is a future where all maize is orange, not white or yellow, and serves the same purpose.

CONSUMERS LOVE IT

Research shows that consumers like food made with Vitamin A orange maize as much as—if not more than—food made with white or yellow maize. **Often, consumers are willing to pay more for orange maize foods, especially when they learn about the health benefits of food made with Vitamin A maize.**

WORLD MAIZE PRODUCTION, 2019



Maize — a globally significant commodity

The maize market is projected to grow at a compound annual growth rate (CAGR) of 3.8 percent during the forecast period (2020-2025). Maize is one of the most widely consumed and utilized staple crops in the world, used for human food consumption, animal feed, brewing, and biofuel production.

Maize was first cultivated at least 7,000 years ago by people living in central Mexico. Today, maize is grown as a cash crop around the world. Production data for the 2018–2019 growing year show the major maize-producing nations are the United States, China, Brazil, Argentina, Ukraine, and India. Maize production in Africa was around 75 million tons in 2018, representing 7.5 percent of world maize production. Maize occupies approximately 24 percent of farmland in Africa.

The European Union (EU) is also major maize producer and consumer. For the 2018–2019 season, the EU was the fifth-largest maize producer globally, with 60.7 million metric tons of maize produced. The EU is, however, a net importer of maize to meet internal demand. The FAO shows that maize is the third most consumed food after rice and wheat.

The importance of Vitamin A & the prevalence of Vitamin A deficiency

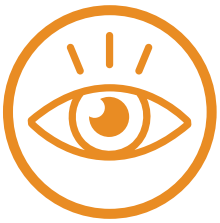
Vitamin A deficiency (VAD): It is the leading cause of preventable blindness in children, it impairs growth and immunity, and increases the risk of severe morbidity from common childhood infections like diarrhea and measles. Vitamin A is a micronutrient that is essential for good health and wellness during all stages of life.

Globally, VAD is one of the most prevalent malnutrition disorders, especially among young children and women of reproductive age. VAD affects approximately 190 million pre-school age children and more than 19 million pregnant women around the world, and is a leading cause of night blindness, affecting nearly 15 million among these populations.

Why do we need Vitamin A? Authorised nutrient function claims for Vitamin A:

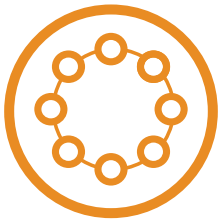
Contributes to the maintenance of normal mucous membranes and important structures of the body

Contributes to the maintenance of normal skin



Contributes to the maintenance of normal vision, especially in dim light

Contributes to the normal functioning of the immune system



Important in cell specialization, most important during pregnancy

Ways to improve foods, food systems, and diets

Many countries have adopted supplementation with large doses of Vitamin A and post-harvest food fortification to address acute and chronic Vitamin A deficiency, especially for young children. These programs are proven, effective interventions.

However, consumer trends in some markets show that consumers prefer foods that contain natural sources of vitamins and minerals, not additional synthetic ingredients on the label (such as synthetic Vitamin A). Consumers are seeking “cleaner” food labels and foods with fewer added ingredients.

Delivering nutrition directly from the plants used as the ingredients for food products is a more cost-effective and sustainable way to meet nutrition needs while addressing consumers’ preferences.

Did your parents ever tell you to “eat your carrots so you can see in the dark?” The Vitamin A found in carrots and Vitamin A maize can prevent night blindness.

How much Vitamin A do we need?

The optimum amount of Vitamin A our bodies need to stay healthy varies depending on several factors, including age, gender, existing Vitamin A status, and current health status. The body absorbs most of the Vitamin A (retinol) from animal source foods and stores it in the liver, from where it is released for utilization according to need. This action helps maintain a steady supply of Vitamin A to all body tissues. The type of Vitamin A in orange maize is beta carotene, and unlike retinol, carotenoid uptake is tightly controlled. The body modulates absorption and conversion of plant-based Vitamin A precursors more stringently. It downregulates absorption and conversion of these carotenoids when Vitamin A storage levels are sufficient; this also minimizes the risk of toxicity because minimal-to-no addition to storage comes from carotenoids if the liver is already filled. There are no food safety or toxicity concerns with Vitamin A maize.

As a guide, 800 micrograms (µg) of animal-based Vitamin A or its plant-based equivalent per day is the recommended daily amount for food labelling purposes and as a general reference for the general population.

Why don't we get enough Vitamin A from our food?

Common sources of Vitamin A are animal source foods (Vitamin A is most abundant in the liver), fortified foods, and supplements. Several fruits and vegetables contain provitamin A carotenoids which can be recognized by the food's appearance, most notably those that are colored red-yellow, orange, or red. This bright pigmentation comes from beta-carotene. In Vitamin A maize, beta cryptoxanthin is important in providing the orange color and produces a yellow flour.

In many low-income, rural food systems, provitamin A-rich fruits and vegetables are seasonal and not available year-round, nor are they generally affordable. Additionally, animal source or fortified foods may not be widely available or consumed in rural and resource constrained households.

Orange maize contains a natural source of Vitamin A that is proven to be bioavailable in several human studies.

Nutritious maize has value throughout the value chain

HarvestPlus varieties of orange maize are a pioneering breakthrough that will be part of the solution to one of the world's biggest problems of malnutrition in low- and middle-income countries, and answer the needs of consumers in higher-income countries.

For Farmers

- I want to grow something that we can eat as a family and is good for us.
- I want to grow crops that are in demand.
- I need varieties with high yield and are easy to grow so I get a good price.

For Food Manufacturers and Retailers

- Orange maize brings news for a category that hasn't seen innovations or growth for many years.
- I want to be ahead of the competition with the latest innovation.
- I want to invest in foods that are not only good for profits and good for consumers, but are good for the world. Social responsibility is good for business.

For Consumers

- I want a naturally more nutritious version of the food I commonly consume.
- I want to buy healthy foods with less added ingredients.
- I want to buy foods that are interesting, colorful and good for me. I want to buy foods that are good for the world, and good for the planet. I care about where my food comes from.

Did you know that climate change and global warming are affecting the nutrient content of crops? Research has shown that the combination of higher concentrations of carbon dioxide (CO_2) in the atmosphere and related higher temperatures depletes protein and nutrient content in plants. The natural nutrient enrichment of crops through plant breeding can counteract this effect.

Maize Nutrition

Communicating nutrition and health claims to consumers

HarvestPlus has developed labelling guidelines for many countries. It is possible to make nutrition content claims and nutrition function claims in compliance with local legislation. For example, and depending on the food format, a product could carry the following claims:

- Natural source of Vitamin A
- Vitamin A is essential for healthy eyesight

Commonly grown maize contains very small amounts of Vitamin A. Depending on the variety and the conditions, HarvestPlus-promoted varieties contain as much 700 micrograms of beta carotene per 100g of maize.

Part of a healthy diet

Recognized as one serving of vegetables.

Gluten free

Does not contain the proteins gliadin or glutenin.

High in fiber

High in fiber when consumed as the whole grain food.

Low fat

Low in saturated fat.

Antioxidants

In addition to beta-carotene, it contains lutein and zeaxanthin, both compounds with antioxidant properties that support good eye health.

Natural color

The vibrant orange color is more attractive to consumers. Health education campaigns are urging consumers to eat a varied, colorful diet.

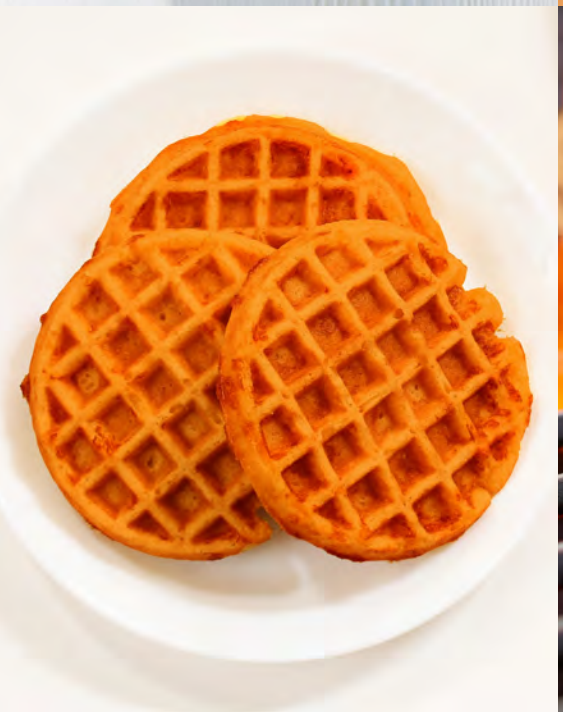
Table 1. Comparison of nutrient composition of orange maize and conventional maize.

Nutrient	Units	Orange Maize	Commonly Grown Maize
Carbohyrdrate	g per 100g	73.4	75.7
Protein	g per 100g	9.6	8.7
Fat	g per 100g	4.2	3.8
Moisture	g per 100g	11.4	10.6
Vitamin A	µg RAE / 100g	117 (15% of the RDA)	17 (2% of the RDA)

Technical information on betacarotene, Vitamin A, and labelling

- Vitamin A orange maize crop contains some carotenoids that convert to Vitamin A (retinol). The target value for carotenoids with ability to convert to Vitamin A is 15 parts per million (ppm), equivalent to 15 micrograms per gram (ug/g), equivalent to 1500 micrograms per 100 gram of commercial grain (ug/100g). This is called provitamin A carotenoids or pVAC. Current varieties have 700 ug pVAC /100g of fresh grain.
- For food labelling purposes, retinol equivalent (RE) or retinol activity equivalent (RAE) is used. The value of pVAC is divided by the conversion factor which is 6 or 12. The 700 ug/100g of pVAC in the current varieties is expressed as 117 ug of RAE per 100 g of commercial grain (using the conversion factor of 6).
- 117 ug of RAE is equivalent to approximately 15 percent of the recommended daily allowance (RDA) of Vitamin A in 100 grams fresh grain, approx. 11 percent water

Product innovation and renovation with orange maize



Maize processing and storage

Since most of the provitamin A carotenoids found in orange maize are located in the endosperm, no major losses occur when milling (dehulling and/or degerming). With appropriate packaging, retention is good for storage and shelf life.

What about aflatoxin contamination?

Aflatoxins (dangerous mold contamination) are a worldwide problem that can have a large impact on the agriculture sector. The aflatoxin problem is a general challenge in agriculture and not specific to Vitamin A maize. Maize is particularly susceptible to aflatoxin due to certain common growing conditions (particularly high temperature and humidity) for the crop. Early evidence suggests that orange varieties may be less susceptible to aflatoxin contamination.

When breeding for nutrition we take a holistic approach and consider all other factors including climate change, yields, and susceptibility to pests and contamination.

The orange varieties' high level of provitamin A carotenoids and other antioxidants is believed to be responsible for this protective effect. However, for all varieties, good agricultural practices and aflatoxin control measures must always be implemented throughout the value chain to minimize the risk of aflatoxin.

How can you get Vitamin A orange maize into your product portfolio?

Build supply chains with HarvestPlus

HarvestPlus and partners have developed and released 65 varieties of Vitamin A maize that are adapted to numerous growing regions and climates of the world. We can work with you to find a maize variety that suits your particular needs.

Working with smallholders farmers

Orange maize is the flagship of the HarvestPlus program. It is a rich source of nutrition for low-income smallholder farming families who also depend on maize as a source of income. HarvestPlus has many years of experience working with maize and can help you find the right maize to grow in the right climate.

HarvestPlus can enable supply chains for you and your business. Depending on the type and volume of maize you are interested in, and the location of your manufacturing facilities, we can enable sustainable, secure supply chains with traceability processes for quality Vitamin A orange maize. Using this route, we find a competitive price and added value, and in so doing, you will be providing market access for the world's most vulnerable smallholders.

Switching to more nutritious maize

It is not always possible to work with smallholders and you may already be working with leading growers and have a strong and dependable supply chain of producers. In this case, we can work with you and your growers to switch your current maize varieties over to the Vitamin A variety. The expert plant breeders, agronomists, and food technologists at HarvestPlus will help at every step of the way. This work provides a revenue stream for our nonprofit organization and, crucially, brings in investment and awareness of the problem and solution. We have several services available to assist with your transition to the naturally nutritious variety.

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