Sweet orange and mandarin fruits are the most popular citrus crops worldwide. Although often mistakenly considered one and the same, oranges and mandarins are different species with specific distinctions. For instance, mandarins are smaller and easier to peel than oranges. Additionally, mandarins are primarily eaten as fresh fruit, whereas most sweet oranges produced in Florida are processed for their juice.

HLB AND FLAVOR
In the United States, prior to the ravages of huanglongbing (HLB), Florida was the largest producer of oranges, and it was Florida’s signature crop. Unfortunately, HLB has drastically reduced orange yields and devastated the Florida citrus industry for over a decade. One of the many devastating effects of this disease is the change in the flavor of oranges. This has had a negative impact on the processed orange juice business.

Therefore, there is a need to adjust orange-processing procedures in an effort to alleviate the negative effects resulting from HLB, such as bitter tasting fruit and the decline in fruit availability. Both of these effects have led to a shortage of raw material required to meet consumer demand. While researching cultivars that appear HLB tolerant, scientists in the citrus breeding program at the University of Florida Institute of Food and Agricultural Sciences Citrus Research and Education Center (UF/IFAS CREC) in Lake Alfred have identified specific mandarin hybrid varieties that demonstrate a high level of HLB tolerance.

COMPARING FRUIT FLAVORS
Interestingly, some of these HLB-tolerant mandarin hybrids produce fruit with a distinctive orange-like flavor yet maintain the physical traits of mandarin fruit. Therefore, understanding the differences between orange and mandarin fruit flavor has generated tremendous interest within the citrus research community. Additionally, a better understanding of orange fruit flavor versus mandarin fruit flavor may support the use of HLB-tolerant mandarin hybrid juice to supplement orange juice products in order to meet consumer demand while sweet orange supplies are low.

To investigate these flavor differences, we conducted sensory evaluations to determine consumer opinions of an HLB-tolerant mandarin with distinctive orange-like flavor.

Aromatic compounds have been used to compare orange varieties and to identify flavor components of satsuma mandarins and mandarin juice. Due to the numerous key aromatic compounds orange and mandarin fruits have in common, characterizing the differences responsible for their flavors is quite complex. Therefore, recently published studies in Yu Wang’s lab at CREC have led to investigations into an unreleased mandarin hybrid known to produce fruit with orange-like flavor to validate the identification of characteristic volatiles of orange-like aroma.

TASTE TESTS
The sensory analysis component of this study was comprised of two tests: the nose-pinch and the pinch-free sensory test. Fifteen trained panelists were exposed to different varieties of fresh-squeezed orange and mandarin juices to become familiar with the flavors.

For the nose-pinch test, panelists blocked their own nasal passage using their thumb and forefinger to pinch their nostrils together while drinking each juice sample. For the pinch-free test, panelists simply drank each freshly squeezed sample (Figure 1) that was randomly presented to them.

Panelists were asked to consecutively taste each juice sample, and then choose the orange juice sample from the two presented. In the nose-pinch test, 40 percent of the panelists selected the correct sample, while 6 percent of the panelists picked the incorrect sample. Notably, the remaining 54 percent...
of panelists were unable to tell the difference between the two samples.

Collected comments indicated that panelists who chose the correct sample based that decision on the idea that “orange juice always tastes sourer than mandarin juice” and “orange juice has a tart taste/aftertaste.” In the pinch-free test, 80 percent of panelists selected the correct sample, 14 percent selected the incorrect sample, and 6 percent could not make a selection (Figure 2). Panelists failing to select the correct sample noted, “I cannot tell which one is orange juice.”

**FLAVOR PERCEPTION**

Flavor perception involves most of our senses. The smell, taste, texture and color of food or drink all influence how we perceive flavor. This perception results as the receptors located along the nasal passageway and on the tongue are activated by the chemical compounds released as food or drink is ingested.

During the nose-pinch test, panelists were limited to solely taste perception as the sensory input to describe each juice sample. Chemically, orange juice is not necessarily sourer than mandarin, nor vice versa.

Sourness and sweetness of orange and mandarin fruit flavor varies by cultivar, as well as from fruit to fruit. So panelists’ interpretations of taste (sourness of the juice) inaccurately influenced their differentiation of orange and mandarin juice samples. The majority of panelists were unable to describe the juice samples using a single perception (taste), suggesting that taste alone cannot identify orange or mandarin fruit flavor characteristics.

Conversely, the combination of aroma perception with taste perception (pinch-free test) allowed panelists to respond with a more accurate interpretation of the flavor for both orange and mandarin juice samples. These results indicate that citrus fruit aroma largely contributes to differentiation of orange from mandarin. The flavor of orange or mandarin fruit is, therefore, the combined perception of both taste and aroma. The general understanding of taste and aroma is that they interact together. The combination of the two are thought to result in a sensation greater than the sum of the perceptions.

It has been demonstrated that the sensory input of taste and smell are linked by the central nervous system.
over time. Additional studies into the
taste-smell association, including eval-
uations of brain scans, indicate aroma
alone may be able to elicit flavor per-
ception. However, taste alone will not.

A follow-up sensory evaluation of
juice from an unreleased mandarin
hybrid was then conducted to validate
the nose-pinch and pinch-free results.
Evaluation of each juice sample was
performed by 16 trained panelists
who were asked to drink the juice and
describe the sample as “orange juice,”
“mandarin juice” or “don’t know,”
and to provide comments relating to
their choice. Sixty-seven percent of the
panelists stated the juice samples were
“orange juice.” Twenty-seven percent
of the panelists chose “mandarin juice”
based on the “thick texture” and 6
percent of the panelists selected “don’t
know” (Figure 3).

**Figure 3.** In the mandarin hybrid juice sen-
sory evaluation, the majority of panelists
stated the sample tasted like orange juice.

**RESEARCH IMPLICATIONS**

Resulting from a cross between
sweet orange and mandarin, this unre-
leased mandarin hybrid developed by
the CREC citrus breeding program
exhibits substantial HLB-tolerance.
Sensory evaluation of this manda-
arin juice flavor indicated an intense
orange-like characteristic, whereas the
juice texture could still be character-
ized as mandarin-like by some. Our
results imply that this mandarin hybrid
fruit not only has potential to confirm
flavor differences between orange and
mandarin fruit in further investiga-
tions, but notably, the characteristics of
this orange-like mandarin fruit suggest
future uses to supplement the orange
juice industry.

Of course, changes to the U.S. Food
and Drug Administration standards of
identity regulations would be necessary
to include more than the maximum
allowable percentage of juice from
fruit not harvested from *Citrus sinensis*
into the product we call orange juice.
Other juice and processing attributes
of new HLB-tolerant cultivars such as
this must be carefully studied to move
forward beyond this first evidence of
proof of concept.

Such a cultivar needs to be assessed
for horticultural performance in order
to ensure that it can meet the needs of
processors and will be profitable for
growers. Florida’s citrus breeders
have identified several candidates
already and are making new crosses
to select more candidates. Working
together with food scientists, the
breeders hope to provide new options
for Florida’s growers to succeed in the
HLB era.

Laura Reuss is a chemist, Fred Gmitter is
a professor, and Yu Wang is an assistant
professor — all at the UF/IFAS CREC in
Lake Alfred.