



Roasted Peanut *Flavor*

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Roasted peanuts are an important peanut product in the United States. Runner peanuts and Virginia peanuts are the two types most commonly grown. Virginia peanuts are often prepared as in-shell, roasted “ballpark” peanuts, while runner peanuts, planted most commonly by Georgia growers, are always roasted after shelling.

The flavor of roasted peanuts is associated with two important reactions, Maillard reaction and lipid oxidation. A Maillard reaction generates pleasant flavor attributes and mainly occurs during roasting. These pleasant flavors gradually diminish with the development of off-flavors during storage. These off-flavors are formed during lipid oxidation, and its effects are known as “flavor fade.”³ In order to retard lipid oxidation, peanut scientists have developed high-oleic cultivars. The following report summarizes recent work on the flavor of roasted peanuts as affected by storage, peanut types, and cultivars.

Peanuts in the United States

The United States is the world’s third-largest producer of peanuts, producing 8 percent of the world’s peanut crop. With about 49 percent of national production, Georgia provides the largest proportion of peanut production in the U.S. Virginia peanuts are commonly used for in-shell roasted peanuts but are also used as the classic, oil-roasted “cocktail” peanuts.⁶ Runner peanuts have uniform kernel size and are mainly planted in Georgia. They have very good roasting characteristics and are often processed further after shelling, mainly into peanut butter. They have a larger kernel size compared to other varieties and are primarily grown in Virginia, Texas, and South Carolina.

Maillard Reaction and Roasted Peanut Flavor

During roasting, a series of physiochemical reactions occur to produce roasted flavor and color change. Maillard reaction is a complicated series of chemical reactions among amino acids and sugars, which generates volatile compounds and pigments called melanoidins that cause brown coloration. Among them, pyrazines are the most extensively studied volatiles due to their contributions to a “roasted” flavor and aroma. Pyrazines start to form at 100 degrees Celsius and rapidly increase in production as temperatures rise to 150 °C.⁴ Mason *et al.* (1966) were the first to identify five different pyrazines and suggested their possible roles in roasted peanut flavor. Baker *et al.* (2003) revealed that 2,5-dimethylpyrazine was the best predictor of roasted peanut flavor. Currently, more than 70 pyrazines are isolated and identified from peanuts. Our lab detected 10 of them from six roasted peanut samples using the technique of headspace solid-phase microextraction/gas chromatography-mass spectrometry (HS-SPME/ GC-MS). We found the highest concentration of 2,5-Dimethylpyrazine during an eight-week storage period, and the high concentration’s strong correlation with roasted peanut flavor was further proved by our work.¹⁰ We also found a close correlation between (E)-2-methyl-6-(1-propenyl) pyrazine and consumers’ rating of roasted peanuts flavor intensity. Davis and Dean (2016) have recently reviewed a detailed description of roasted peanut flavor, and Figure 1 presents brief descriptions of medium-roasted shelled peanuts used in a study done in our lab.¹⁰



GA 06G

Normal-oleic runner-type peanut variety developed by University of Georgia's Coastal Plain Experiment Station in Tifton, Georgia, and released in 2006. It has high yield, large seed size, an excellent shelling rate, and good resistance to the spotted wilt disease caused by tomato spotted wilt virus (TSWV).



GA 13M

High-oleic runner-type peanut variety created by at the University of Georgia's Coastal Plain Experiment Station in Tifton, Georgia, and released in 2009. It has high yield, small seed size, resistance to TSWV, and oxidation. Our study showed that this variety maintained roasted flavor better than the rest.



Runner (mixed)

Mixed commercial runner-type peanuts. Runner peanuts mainly grow in Georgia. They have uniform, medium-sized kernels, which allow for even and uniform roasting. This type is very popular in the peanut industry, commonly used for shelled roasted peanuts, peanut butter, etc.



Virginia (mixed)

Mixed commercial Virginia-type peanuts. Virginia peanuts are typically produced in Virginia and North Carolina. They have large peanut pods containing two or more large kernels. This type accounts for most in-shell roasted peanuts.

Figure 1. Medium-roasted peanuts used in the study by Wang *et al.*, 2017.

See <http://georgiacultivars.com/cultivars/peanuts>.

Lipid Oxidation and Off-Flavors

Lipid oxidation is a major concern in the peanut industry because of the high lipid content of peanuts, which varies from 44 percent to 56 percent in major market peanut types. Roasting and storage of the finished product has a major impact on the extent of lipid oxidation. Both dry roasting and oil roasting at high temperatures leads to the breakdown of the microstructure of the kernels, promoting lipid oxidation.² Lipid oxidation is also known to be a mechanism that increases peanut volatiles throughout storage.⁹ During oxidation, unsaturated lipid molecules first transform to hydroperoxides, which are the primary non-volatile oxidation products. Then hydroperoxides decompose to various volatile aromatic secondary products, including alcohols, aldehydes, ketones, furans, organic acids, and hydrocarbons. Most of these secondary oxidation products are responsible for the oxidized flavor in peanuts. However, the flavor threshold of hydrocarbons is very high (90-2150 ppm,

or parts per million), making this group the least probable cause of off-flavors. Our lab detected five aldehydes, one ketone, and one alcohol from roasted peanuts during eight weeks of storage. The origins of these compounds are shown in Table 1.

Compounds	Origins
Hexanal	Linoleic acid
Heptanal	Oleic and linoleic acid
Nonanal	Oleic acid
Octanal	Oleic and linoleic acid
2,4-Decadienal	Linoleic acid
3-Nonen-2-one	Linoleic acid
1-Octen-3-ol	Linoleic acid

Table 1. Origins of selected secondary oxidation products.

Our results showed that all of these oxidation products had a strong positive correlation with an oxidized flavor and negatively correlated with roasted peanutty flavor. Among them, octanal and nonanal were the best predictors of the overall oxidized flavor. As storage time increases, more off-flavors gradually appear. The first is a cardboard-like flavor, which relates to oxidized products in their early stages of oxidation, followed by a fish-like and then a paint-like flavor. Due to the short storage period (8 weeks) in our study, the intensity levels of these three off-flavors were close to zero.

Flavor Fade

Flavor fade is a common phenomenon that occurs during the storage of roasted peanuts. Flavor fade in roasted peanuts is defined as the decrease of pleasant flavor attributes—roasted peanut flavor and sweet taste—accompanied by the development of off-flavors. The mechanism for flavor-fade is still unclear. Warner *et al.* (1996) indicated that the concentration of pyrazines was not reduced during storage, so they concluded that the loss of roasted flavor resulted from the masking of pyrazines by aldehydes (oxidation products). Other researchers did observe a decrease in pyrazines, which may be responsible for the loss of roasted flavor.¹² In most peanut samples from our study, we detected a reducing trend in total pyrazine concentration, although the change was not significant. It is possible that a greater change would appear if the storage period were extended. Williams. (2006) considered that the degradation of pyrazines was caused by lipid radicals and hydroperoxides from lipid oxidation.



Flavor fade also affects consumers' acceptance of roasted peanuts. Our results showed that when buying peanuts, **flavor** was the most important consideration followed by **price** and **texture**. In addition, flavor had the largest contribution to overall consumer approval of roasted peanuts. From the aspect of aroma profile, all aldehydes had a strong negative correlation with consumer overall liking; while only three out of ten pyrazines ((E)-2-Methyl-6-(1-propenyl) pyrazine, 2,3-dimethyl-5-ethylpyrazine, and 2,5-dimethyl- pyrazine) had a moderate positive correlation with consumers' overall liking. This suggested that aldehydes might be better predictors of consumer liking of roasted peanuts than pyrazines.

High-Oleic Trait

Unsaturated fatty acids, mainly oleic (18:1 n-9) and linoleic acids (18:2 n-6), consist of approximately 80 percent of oil in peanuts. Linoleic acids are essential fatty acids for humans, but they are vulnerable to lipid oxidation compared to oleic acids due to multiple double bonds in their structure. Thus, the ratio of oleic to linoleic acids is regarded as an indicator for rate of lipid oxidation. In order to extend shelf life, high-oleic cultivars are developed. GA 13M is one of them. Compared to normal-oleic runner cultivar GA 06G, the current top choice for runner production, high-oleic GA 13M had higher consumer likings, such as overall liking, liking of flavor, sweetness and roasted peanut flavor, during eight weeks of storage. GA 13M also had lower oxidation products and a better capability to maintain pyrazines during storage.

Some researchers did not observe different consumer likings between normal- and high-oleic roasted peanuts.⁷ Baker *et al.* (2003) found that roasted high-oleic (SunOleic97R) peanuts had the least roasted peanut flavor and aroma under all roasting conditions. However, Nepote *et al.* (2009) pointed out that consumer acceptability of high-oleic peanuts depended on specific cultivars. Moreover, previous research stated that high-oleic roasted peanuts generated less oxidized flavors with better persistence of roasted flavor during storage.⁷ Therefore, a higher consumer acceptability of high-oleic GA 13M might take advantages from the characteristics of this cultivar, including better resistance to oxidation. The main limitation of our study on roasted peanuts was that it was based on a single-season harvest.

The Future of Roasted Peanut Flavor

To consumers, flavor is the most important attribute of roasted peanuts, which makes flavor fade a serious concern for the peanut industry. The rate of flavor fade is influenced by several factors involving peanut types and cultivars. Based on our research work, we can infer that utilization of high-oleic lines (like GA 13M) is a promising solution for the flavor fade problem in roasted peanuts. Further work on flavor of roasted peanuts and other products such as peanut butter and flavored peanut pastes is necessary to prove the points discussed in this paper by applying a longer storage period and multiple-season-harvested crops.

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