FRUITY FERMENTED OFF-FLAVOR DISTRIBUTION IN SAMPLES FROM LARGE PEANUT LOTS

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ABSTRACT

Fruity fermented (FF) off-flavor develops when immature peanuts are cured at excessive temperatures (>35C). The objective of this study was to characterize FF distributions and determine the variability among samples from large peanut lots. Twenty peanut lots identified as having a range of FF off-flavor were sampled. Twenty samples from each lot were roasted and processed into paste for descriptive sensory analysis. Differences in FF intensity were noted within and among lots. The FF intensity mean of the lots was either greater or less than the median value for the samples, indicating that the distributions were skewed. The skewed distributions and the variation among samples from a single lot demonstrated the need to develop a sampling plan for FF off-flavor.

PRACTICAL APPLICATIONS

The peanut manufacturing industry has a stated concern for fruity fermented (FF) off-flavor in peanuts purchased for use in peanut products, but there is difficulty in obtaining a truly uniform sample of all peanuts in a large lot. This study measured the variability and characterized the FF distribution among samples from bulk peanut lots, and will be used to estimate the components contributing to FF variation within peanut lots and aid in the

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development of sampling plans for accurate FF intensity determination. This type of research has relevance to a wide range of food factors where the factor of interest is not homogeneously distributed in a commodity or product.

**INTRODUCTION**

The driving force for consumer purchase and consumption of peanuts and peanut products is the roasted peanut flavor (Sanders et al. 1997). In 2005, approximately 2,187 million tons of peanuts were produced in the U.S.A. (Peanut Production Statistics 2005) and most are used in the domestic edible trade. One of the major concerns of the peanut industry, and other food industries, is the presence of off-flavors as consumers are generally not accepting of differences or variations in the flavor of products. Off-flavor development can occur during production, handling, processing and storage. Fruity fermented (FF) off-flavor is one of the most common off-flavors in peanuts and is due to environmental factors at harvest when the early stages of peanut curing occur. Research has demonstrated that FF off-flavor may be developed during curing of immature peanuts when temperatures exceed 35°C (Sanders et al. 1989b). Greene et al. (2006) reported that consumers were able to detect FF off-flavor in peanuts using two different sensory scaling techniques. The presence of FF off-flavor significantly lowered consumer perception of roasted peanut flavor and negatively impacted overall liking of the product when a line scale, the most sensitive method, was used. The peanut industry has a stated concern for FF off-flavor in peanuts purchased for the manufacture of peanut products (American Peanut Council, personal communication), and the assumption can be made that data from proprietary studies form the basis for the concern. Anecdotal information from crop years when FF was more common indicated the rejection of hundreds of tons of peanuts when FF was identified by manufacturers after delivery of commercially tested lots.

Peanut plants flower indeterminately and peanuts of different physiological maturity are found on the plant at any harvest time. Because peanuts tend to become big before they are fully mature, peanuts of each physiological maturity class are found in all grade sizes (Sanders 1989; Sanders and Bett 1995). Although more immature peanuts are found in smaller grade sizes, even the larger sizes contain some physiologically immature peanuts. Sanders et al. (1989a) reported significant differences in roast color and flavor of medium grade-size peanuts from different maturity classes. Immature peanuts roast darker and are more likely to develop FF off-flavor compared to mature peanuts (Sanders et al. 1989b). Thus, because immature peanuts are more likely to have FF off-flavor, the distribution of the various maturity classes within a lot is correlated to the FF intensity distribution in the lot. This heterogeneous, random distribution of immature seed, that may contain FF
off-flavor, results in difficulty in obtaining a truly uniform sample of all peanuts in a large lot. It is important for peanut product manufacturers to have an accurate determination of FF intensity, if it is present within a single lot.

Descriptive sensory analysis by trained panelists is a powerful tool used for the detection (discrimination) and description of both the qualitative and quantitative sensory components of a consumer product (Meilgaard et al. 1999). The peanut lexicon, developed by Johnsen et al. (1988), includes terms such as, roasted peanut flavor, sweet aromatic, dark roast and woody/hull/skins. Sanders et al. (1989a) added the FF descriptive term to the previously published peanut lexicon. The characterization of FF off-flavor has been investigated using descriptive sensory panels and can be detected at intensity levels as low as one using the Spectrum method (Sensory Spectrum, Inc., New Providence, NJ).

Food manufacturers use acceptance sampling plans to obtain the best estimate of a wide range of factors in numerous commodities (Vandeven et al. 2002). Quality factors of raw peanuts vary because of different weather conditions, seed varieties, cultural practices and processing. Sampling plans have been used by buyers and sellers for detection of various heterogeneous contaminants, such as aflatoxin and other mycotoxins (Whitaker 2003). Operating characteristic (OC) curves can be generated to determine how a particular sampling plan will perform, thus estimating the potential magnitude of bad lots accepted (buyer’s risk) and good lots rejected (seller’s risk) (Vandeven et al. 2002; Whitaker and Johansson 2005). The design of sampling plans to determine the level of aflatoxin contamination has been reported throughout the literature; however, there have been no research studies on establishing the variability of FF in large lots or developing sampling plans for FF off-flavor. Determination of the variability and distribution of FF intensity among individual samples within a lot is necessary for development of sampling plans that can be used to accurately determine with high confidence the true intensity of FF in a lot (Vandeven et al. 2002).

Descriptive sensory analysis of numerous samples from many large peanut lots is necessary to determine the FF distribution within lots. The objective of this study was to measure the variability and characterize the FF distribution among samples from bulk peanut lots. This type of research has relevance to a wide range of food factors where the factor of interest is not homogeneously distributed in a commodity or product. A sampling plan that results in sufficient numbers and size of samples to provide an accurate estimate of some factors is critical to detection and/or elimination of that factor.

MATERIALS AND METHODS

Twenty, 1-ton lots of medium grade-size runner-type peanuts (2003 crop) were identified as having a range of FF off-flavor by a single commercial
The commercial analysis is a descriptive sensory analysis using five highly trained panelists and a roasted, pasted sample from a random 300-g sample. The range of FF intensities within the 20 lots was reported to be from 0 to 4 and based on that analysis, the lots were selected for inclusion in the study by commercial sheller personnel. Large samples (200 lbs) from the 20 different lots were obtained from the shellers and each sample was riffle-divided to obtain 20 samples of 680 g each. The 400 samples (20 lots × 20 samples) were roasted in a lab-scale roaster (Aeroglide Corporation, Raleigh, NC) at 176°C for ca. 12 min to a target roast color of Hunter \(L = 50 \pm 1\). Roasted peanuts were cooled using forced ambient air, seed coats were manually removed and 250 g of each sample was ground into a paste following the procedures of Sanders et al. (1989a). Peanut pastes were stored in 8-oz glass jars at −4°C and tempered to room temperature (20°C) the day before sensory analysis.

A trained descriptive panel evaluated the flavor of the 400 peanut paste samples. The sensory panel consisted of seven members each with over 500 h of experience with descriptive sensory analysis of peanut flavor including FF. Panelists evaluated seven samples per panel session using all the terms in the peanut lexicon (Johnsen et al. 1988; Sanders et al. 1989a). Samples from several different lots were randomly presented to the panel to avoid panelist bias. After each sample, panelists expectorated peanut pastes and rinsed their mouths with water and cleansed their palates with unsalted crackers. The Spectrum method was used for descriptive sensory analysis. This method utilizes a universal intensity scale (0 to 15), in which panelists score intensities of all attributes on the same basis (Drake and Civille 2003). Mean, SD, median and coefficient of variation (CV) of all samples from a lot were calculated.

RESULTS AND DISCUSSION

There were differences in FF off-flavor intensity of samples within and among the 20 peanut lots. Mean FF intensities for the 20 lots ranged from 0.2 to 2.1. Sampling issues are evident from this information alone because some of the 20 lots were originally identified by one commercial analysis as having no FF off-flavor. FF intensity among samples from a single lot was highly variable (Table 1). Lot 2816 had a FF intensity mean of 0.2 with samples ranging from 0 to 0.6. Trained panel threshold intensity is considered to be 1 and mean values below 1 indicate that all panelists did not identify FF in the sample. The FF off-flavor intensity mean for Lot 1022 was 0.9 and the range of sample intensities (0.2–1.9) within this lot is much wider than the range in Lot 2816. Lot 1039 had a FF mean of 2.1 and the range among samples was 1.4–2.8. Lot 1040 had a FF intensity mean of 2.1 and the range of sample
intensities was 0.9–2.8. Each peanut lot had a relatively wide range of FF off-flavor intensity in individual samples which further demonstrated the difficulty associated with obtaining an accurate determination of off-flavor intensity with a single sample from a lot.

Table 1 shows the mean, median, SD, CV and range of FF intensities among the 20 lots. The SD, CV and range of FF intensities among samples from a lot indicated variability, whereas the mean and median provide some indication of the shape of the distribution (normal versus skewed). The mean and median FF intensities for each of the 20 lots were compared among the 20 samples to determine whether FF distributions were normal or skewed. When the FF mean of a lot is equal to the median (mean = median), the distribution among samples is normal (symmetrical). However, if the median is greater or less than the mean (median > or < mean), the FF distribution is negatively or positively skewed (nonsymmetrical). If samples from a peanut lot indicate a normal distribution, 50% of the samples from that lot are less than the FF intensity mean, while the other 50% are greater than the FF intensity mean. A positively skewed distribution indicates that more than 50% of the samples from the lot have lower intensity of FF than the FF intensity mean and less than

### Table 1.

<table>
<thead>
<tr>
<th>Lot #</th>
<th>Mean</th>
<th>Median</th>
<th>SD (±)</th>
<th>CV (%)</th>
<th>Range (low–high)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2816&lt;sup&gt;+&lt;/sup&gt;</td>
<td>0.2</td>
<td>0.1</td>
<td>0.2</td>
<td>105</td>
<td>0.0–0.6</td>
</tr>
<tr>
<td>1075&lt;sup&gt;+&lt;/sup&gt;</td>
<td>0.3</td>
<td>0.2</td>
<td>0.3</td>
<td>100</td>
<td>0.0–0.9</td>
</tr>
<tr>
<td>1086&lt;sup&gt;+&lt;/sup&gt;</td>
<td>0.6</td>
<td>0.6</td>
<td>0.4</td>
<td>65</td>
<td>0.1–1.2</td>
</tr>
<tr>
<td>1093&lt;sup&gt;+&lt;/sup&gt;</td>
<td>0.8</td>
<td>0.8</td>
<td>0.5</td>
<td>64</td>
<td>0.0–2.0</td>
</tr>
<tr>
<td>1022&lt;sup&gt;-&lt;/sup&gt;</td>
<td>0.9</td>
<td>0.8</td>
<td>0.5</td>
<td>54</td>
<td>0.2–1.9</td>
</tr>
<tr>
<td>6363&lt;sup&gt;-&lt;/sup&gt;</td>
<td>1.0</td>
<td>0.9</td>
<td>0.5</td>
<td>51</td>
<td>0.2–1.7</td>
</tr>
<tr>
<td>1035&lt;sup&gt;-&lt;/sup&gt;</td>
<td>1.0</td>
<td>0.8</td>
<td>0.5</td>
<td>48</td>
<td>0.3–1.9</td>
</tr>
<tr>
<td>2821&lt;sup&gt;-&lt;/sup&gt;</td>
<td>1.1</td>
<td>1.0</td>
<td>0.7</td>
<td>68</td>
<td>0.0–2.4</td>
</tr>
<tr>
<td>1036&lt;sup&gt;-&lt;/sup&gt;</td>
<td>1.1</td>
<td>0.9</td>
<td>0.6</td>
<td>54</td>
<td>0.3–2.2</td>
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<tr>
<td>1087&lt;sup&gt;-&lt;/sup&gt;</td>
<td>1.1</td>
<td>1.1</td>
<td>0.8</td>
<td>76</td>
<td>0.00–2.3</td>
</tr>
<tr>
<td>1034&lt;sup&gt;-&lt;/sup&gt;</td>
<td>1.1</td>
<td>1.2</td>
<td>0.4</td>
<td>38</td>
<td>0.2–1.8</td>
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<tr>
<td>1020&lt;sup&gt;-&lt;/sup&gt;</td>
<td>1.1</td>
<td>1.0</td>
<td>0.6</td>
<td>52</td>
<td>0.2–2.0</td>
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<tr>
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<td>1.2</td>
<td>1.1</td>
<td>0.5</td>
<td>47</td>
<td>0.4–2.6</td>
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<tr>
<td>1041&lt;sup&gt;-&lt;/sup&gt;</td>
<td>1.2</td>
<td>1.2</td>
<td>0.6</td>
<td>53</td>
<td>0.0–2.3</td>
</tr>
<tr>
<td>1065&lt;sup&gt;-&lt;/sup&gt;</td>
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<td>1.3</td>
<td>0.8</td>
<td>60</td>
<td>0.1–2.8</td>
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<td>1063&lt;sup&gt;-&lt;/sup&gt;</td>
<td>1.4</td>
<td>1.3</td>
<td>0.6</td>
<td>42</td>
<td>0.5–2.5</td>
</tr>
<tr>
<td>1067&lt;sup&gt;-&lt;/sup&gt;</td>
<td>1.6</td>
<td>1.7</td>
<td>0.6</td>
<td>40</td>
<td>0.4–2.5</td>
</tr>
<tr>
<td>1064&lt;sup&gt;-&lt;/sup&gt;</td>
<td>1.7</td>
<td>1.6</td>
<td>0.4</td>
<td>27</td>
<td>1.1–2.4</td>
</tr>
<tr>
<td>1039&lt;sup&gt;-&lt;/sup&gt;</td>
<td>2.1</td>
<td>2.1</td>
<td>0.3</td>
<td>16</td>
<td>1.4–2.8</td>
</tr>
<tr>
<td>1040&lt;sup&gt;-&lt;/sup&gt;</td>
<td>2.1</td>
<td>2.2</td>
<td>0.5</td>
<td>24</td>
<td>0.9–2.8</td>
</tr>
</tbody>
</table>

+, positively skewed distribution; –, negatively skewed distribution.
50% of the samples are higher than the FF intensity mean. The evaluation of skewedness for the 20 peanut lots indicated that 15 of the 20 lots were positively skewed and five were negatively skewed, and there were zero normal distributions. Of the five negatively skewed distributions, two were extremely close to being normal distributions. In the 15 positively skewed lots, a single sample had a greater probability of underestimating the true FF intensity of the lots than overestimating (increased buyer’s risk), and in the five negatively skewed lots there was a greater chance of overestimating the true FF intensity (increased seller’s risk).

CV (SD/mean × 100), which is a relative measure of variability, generally decreased as the mean FF intensity increased, indicating that there is more variability among lots with low FF off-flavor (Table 1). A lot with high FF intensity is more likely to be identified even in a small sample size. In contrast, a low level of FF intensity within a lot will be more difficult to detect. These relationships are possibly in part related to the fact that more individual seed in a high FF intensity lot have FF off-flavor and are thus more likely to be collected in an individual sample (i.e., the lot has a maturity class distribution with greater percentage of immature seed). Whereas, a sample from a low FF intensity lot, in which there are fewer seed with FF off-flavor (low percentage of immature seed) is less likely to contain a proportionate amount of the seed with FF off-flavor.

FF intensity distributions of three lots with low (Lot 2816), medium (Lot 1034) and high (Lot 1039) FF off-flavor intensity are depicted in Fig. 1. Lot 2816 had the lowest FF intensity mean (0.2) and exhibited a positively skewed distribution in which a single sample was more likely to underestimate the true lot mean (13 samples versus 7 samples). Lot 1039 had a high FF intensity mean (2.1) and was also positively skewed (13 samples versus 7 samples). Lot 1034 had a negatively skewed distribution in which a single sample was more likely to overestimate the true lot mean (9 samples versus 11 samples). Regardless of the underlying FF distribution among individual kernels in the lot, as sample size increases, the distribution becomes more normal and provides a more precise determination of the true FF intensity of the off-flavor in a lot (Whitaker and Johansson 2005).

Currently, the peanut industry uses a 300-g sample to evaluate the presence of FF off-flavor. In this study, a 250-g sample was used to determine FF off-flavor intensity and the variability should approximate the use of a single commercial analysis of 300 g. Development of sampling plans can be accomplished with data from any sample size, because it involves partitioning of the source of error and eventual calculation of OC curves to determine the effect of various sample sizes on the likelihood of obtaining a true measure of the FF intensity. Previous studies on mycotoxins have suggested that as sample size increases, the probability of accepting bad lots (false negative) and rejecting
good lots (false positive) decreases (Whitaker and Johansson 2005). An increase in sample size to identify FF off-flavor decreases the variance, which increases precision and reduces misclassification of lots. It is important for manufacturers to obtain an accurate determination of FF off-flavor to prevent the misclassification of large peanut lots. Whether the peanut lot had a low or high mean, the distribution of FF off-flavor was highly variable within a lot, indicating that the current commercial method using only one 300-g sample may be inadequate to supply accurate FF data. In order to obtain a precise estimation of a factor of concern, the sample size, sample preparation, sub-sampling and analytical methods must be investigated (Vandeven et al. 2002).

CONCLUSIONS

Large peanut lots were shown to have high sample-to-sample variability of FF intensity. Determination of the variability and FF distribution among samples is necessary for the development of accurate sampling plans for bulk
lots. The data collected in this study will be used to estimate the components contributing to FF variation within peanut lots and aid in the development of sampling plans for accurate FF intensity determination. The use of sampling plans is a cost-effective way to reduce the risk of good lots being rejected (seller’s risk) and bad lots being accepted (buyer’s risk). The findings in this study demonstrated the critical need to develop sampling plans for a wide range of commodities in order to accurately determine the sensory quality, when that quality is not homogenously distributed in the commodity or product.

REFERENCES


