Roasted Peanut Flavor and Related Compositional Characteristics of Peanut Kernels of Spring and Fall Crops Grown in Taiwan

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Spring and Fall crops of peanut are grown each year in Taiwan. A general consumer concept indicating that the roasted peanut flavor of the kernels of the former is inferior to the latter deserves further investigation. Tainan 11 and Tainan 12 (Spanish cultivars) were consecutively grown for two crops in an experimental field with green pea for rotation and harvested 70 days after flowering. In compositional analyses of the sound and mature kernels, the ratio of the contents of typical and atypical flavor precursors of free amino acids (T:AT) was higher while the sucrose content was lower in the kernels of Fall crops than those of Spring crops. In headspace analysis, the total volatile content varied insignificantly while the sulfur volatile content was higher in the kernels of Spring crops. When the kernels were roasted and subjected to peanut oil and flavor extraction and GC-MS analysis of the pyrazine compounds, the contents of the total pyrazines and most of the peanut flavor-related pyrazines were higher in the kernels of Fall crops than those of Spring crops.

Keywords: *Peanut; peanut flavor; growing season; free amino acid; headspace analysis; pyrazine; GC-MS*

INTRODUCTION

Peanut production in Taiwan is unique. Spring and Fall crops are grown each year. In general, Spring crops are planted in February in southern Taiwan and in March in northern areas and harvested in June and July, respectively. Fall crops are planted in July and August and harvested in November and December from the south to the north. Taiwan is located in tropical and subtropical areas, and its geographical nature and weather pattern vary considerably with location. The weather pattern during the planting period of Spring and Fall crops varies in a reverse manner. During the late cultivation period until time of harvest, monsoon and draught seasons are occasionally encountered by the two crops, respectively. As an ancestral concept, consumers believe that the roasted peanut flavor of the kernels of Spring crops is inferior to kernels of Fall crops. However, in the literature, roasted peanut flavor performance and related characteristics between kernels of Spring and Fall crops have been meagerly studied.

The potential of raw peanut kernels to generate a unique "peanutty" flavor during roasting is one of the most important considerations in quality evaluation. Free amino acids and monosaccharides in kernels are essential precursors for development of the roasting flavors (Newell et al., 1967; Mason et al., 1969; Oupadissakoon and Young, 1984). Newell et al. (1967) and Cobb and Johnson (1973) separated amino acids into precursors associated with the production of typical roasted peanut flavor and precursors associated with atypical roasted peanut flavor or off-flavor. The former includes aspartic acid, glutamic acid, glutamine, asparagine, histidine, and phenylalanine, while the latter includes threonine, tyrosine, lysine, and arginine. Pattee et al. (1982) have suggested that a ratio of the sum of the concentration of the typical roasted peanut flavor precursors (T) to the atypical roasted peanut flavor precursors (AT) might serve as an index of the potential for good roasted flavor quality. The agreement between increasing T:AT ratio and roasted flavor scores is supportive of the practicability of the T:AT ratio. In this study, Spring and Fall crops of peanut were planted in the same experimental field with green pea as a rotation crop under the same cultivation practice. Sound and mature peanut kernels were subjected to analyses including determinations of free amino acid, sucrose, and fatty acid contents. The kernels were further subjected to headspace volatile analysis and dry-roasted to an appropriate state to enhance peanut flavor formation followed by flavor analyses with gas chromatography (GC) and GC-mass spectrometry (GC-MS).

MATERIALS AND METHODS

Peanut Cultivation and Harvesting. Peanuts of Tainan 11 and Tainan 12 (Spanish cultivars) were grown in an experimental field located in Sueshan, Chiayi, Taiwan. Two crops of peanut were consecutively grown on half of the field with vegetable green pea for rotation. Spring crops of peanut were grown on February 27 and harvested on June 20, 1996. For Fall crops, the growing period was from September 3 to December 10, 1996. Triplicate plots (2 × 5 m for a plot) for each cultivar and 200 seeds were planted in each plot. Peanuts were dug 70 days after flowering. Mature peanut pods were detached right after digging. Mature pods (brown and black

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Hull−Scrape classes) (Rucker et al., 1993) were sun-dried on a cement slab. The dried pods were shelled manually. Pods containing at least one shriveled kernel were designated as immature and separated. Sound kernels from mature pods were sieved (1.92 × 0.6 cm, U.S. No. 1 standard), and U.S. No. 1 graded kernels were stored at −25 °C prior to freeze-drying and compositional analyses.

Free Amino Acid, Sucrose and Fatty Acid Analyses. Freeze-dried kernels were skinned manually and hydraulically pressed (150−170 kg/cm^2) to extract peanut oil and to prepare partially defatted peanut meals. The oils were deposited in amber vials, nitrogen-flushed, screw-capped, and stored at −25 °C until further analysis. The partially defatted meals were further defatted with *n*-hexane at −20 °C to prepare *n*-hexane-defatted flours and subjected to analyses of free amino acid composition and sucrose content (Chiou, 1997). For analysis of fatty acid composition, the procedure reported by Chiou et al. (1997) was followed.

Headspace Analysis of the Peanut Kernel Volatiles. Mature and sound peanut kernels obtained from Spring and Fall crops were subjected to volatile characterization using a headspace analysis technique with minor modification (Young and Hovis, 1990). For each sample, 35 g of peanuts was ground in a Krups 75 coffee mill to 25 ± 10 mesh size. Ground peanuts (15 g) were weighed into a 12 mL glass vial which was capped and sealed with silicon rubber/Teflon faced septa and a crimp cap (Tekmar-Dohrmann, Cincinnati, OH). The vial was heated for 12 min at 150 °C in a Tekmar autosampler Model 7000/7050. Two milliliters of the headspace volatiles was automatically injected into a Shimadzu 15A gas chromatograph (Kyoto, Japan) through a 110 °C transfer line. The chromatograph was fitted with a 1.1 m × 2.6 mm i.d. glass column packed with 60/80 mesh Tenax GC (Teklab, Baton Rouge, LA) and with photoionization (PID) and flame ionization (FID) detectors in series. Only FID peak data were used in this study. The column was conditioned at 275 °C for 16 h. Nitrogen carrier gas flow was adjusted to approximately 50 mL/min so that hexanal eluted at 5 ± 0.05 min. The column oven temperature was initiated at 105 °C and held 0.5 min, and then programmed to increase (15 °C/min) to 225 °C and held 1.5 min. The injector temperature was 200 °C, the detector temperature was 220 °C, and the range was set at 1. Peaks were integrated using the EZChrom chromatography data system, version 6.2 (Scientific Software Inc., San Ramon, CA). Headspace analysis was performed on selected standard chemicals to determine the retention time. A 1.5 g peanut oil sample was spiked with a standard chemical for headspace analysis.

Roasted Peanut Flavor Extraction and Concentration. Peanut kernels, 500 g for each batch deposited in a rolling punctured stainless-steel drum (6 cm i.d. and 22 cm length), were roasted in an electric oven (Sanyo SK-7200M with 27 × 28 × 35 cm of the internal space) set at 200 °C. Prior to deposit for roasting, some kernels were manually skinned and incorporated as an roasting indicator based on color change during roasting. The kernels were roasted up to an extent of moderate roast when the indicators have changed their color from milky to yellow and slightly brown. An identical extent of roasting among batches was monitored by fine adjustment of roasting time according to the color change of the skinned kernels. Two batches of kernels from each cultivar and crop were roasted, and roasting times were 30 ± 1.5 min among batches. After spreading of the roasted kernels on a tray and cooling to ambient temperature, the kernels were skinned for color checking and subjected to peanut oil extraction using a hydraulic press conducted at 150−170 kg/cm^2. The oil was centrifuged (Hitachi SCR-20B, Rotor RPR 12-2-1330, set at −10 °C, 10000 rpm, and 10 min), and the supernatant oil was sealed in an amber vial and stored at −18 °C for further analysis.

For volatile compound extraction, the vial-stored oil was removed from a freezer and tempered at ambient temperature until melted completely, from which 100 g was withdrawn and deposited into a flask of a Likens−Nikerson (LN) apparatus for simultaneous steam distillation and solvent extraction. Dichloromethane was used as an extraction solvent. After 2 h of refluxing, an aliquot of 3 mL of 0.01% naphthalene was added as an internal standard, and the extracted solution was subjected to phase separation using a separation funnel. The collected dichloromethane solution was further dehydrated by anhydrous Na_2SO_4. The dehydrated solution was concentrated to 30−50 μL using a column (840 × 16 mm) packed with glass beads (acid-washed, 0.71−1.18 mm; Sigma Chemical Co., St. Louis, MO) monitored at 45 °C by wrapping with a heating tape. The concentrate was then deposited in a capillary glass tube (70 × 2 mm) and further concentrated in a water bath at 45 °C. The final concentrate (ca. 10 μL) was sealed and kept at −18 °C for further analysis.

Identification and Quantitation of Volatile Compounds. A gas chromatograph (HP 5890 II, Hewlett-Packard Co., CA) equipped with a FID detector and an HP-Innowax column (30 m length, 0.25 mm i.d., and 0.15 μm film thickness) was used for quantitative analysis of the volatile compounds in the concentrates. The column oven temperature was initiated at 40 °C for 5 min and programmed to increase the temperature to 240 °C at 2 °C/min and held for 50 min. The detector temperature was 270 °C. Helium as carrier gas was monitored with flow rate of 28.5 cm/s. The injection volume and temperature were 1.0 μL and 250 °C, respectively. Identification of the volatile compounds was performed with HP 5890 II GC coupled with HP 5972 MSD (mass selective detector). The gas chromatography conditions were identical to those of quantitative analysis described above except that the FID detector was substituted with a MSD. The temperature and ionizing voltage of the GC-MS transfer line were 265 °C and 70 eV, respectively. Data were collected using a HP G1030A VL24/66 ChemStation controller interfaced with HP 1034C MS ChemStation software. The mass spectrometer was initiated automatically 5 min after sample injection. The mass fragments between 40 and 400 amu were detected and integrated in a total ion chromatogram. Unknown peaks were identified based on the retention index and in comparison with the reference spectra from HP G1035A MS ChemStation Libraries. In this study, pyrazine compounds were identified and quantitated for peanut flavor characterization.

Statistics. At least duplicate experiments were conducted. Means with standard deviation are reported. Analysis of variance (ANOVA) at the 5% level was applied to analyze the variance in the pooled data of the determinations of free amino acid, sucrose, fatty acid, headspace volatile, and pyrazine contents between Spring and Fall crops of peanuts of Tainan 11 and Tainan 12 using JMP software (SAS Institute Inc., Cary, NC). The analysis was followed by pair comparisons through Student's *t* test. Based on a preliminary statistical analysis between peanut cultivars of Tainan 11 and Tainan 12, the effect of cultivar was observed mostly insignificant and could be ignored. Then the data obtained from the two cultivars were pooled to address the effect of growing season in this report.

RESULTS AND DISCUSSION

Free amino acid compositions of the peanut kernels of Spring and Fall crops of Tainan 11 and Tainan 12 are presented in Table 1. Each free amino acid content varied as functions of growing season and nature of individual amino acids. In comparison, significantly higher aspartic acid, threonine, isoleucine, and tyrosine contents while lower serine, leucine, and lysine contents were observed in Spring crops than in Fall crops ($p < 0.05$). Total amino acid contents were 10.01 and 8.42 mg/g of protein for kernels of Spring and Fall crops, respectively. Since free amino acids are essential precursors for the development of the roasting flavor of peanut kernels (Newell et al., 1967; Mason et al., 1969; Oupadissakoon and Young, 1984), roasting flavor performance is closely related to the profile of free amino acids in kernels during roasting. Newell et al. (1967) and Cobb and Johnson (1973) separated aspartic acid,

Table 1. Analysis of Variance (ANOVA) of Free Amino Acid Contents between the Kernels of Spring and Fall Crops of Two Spanish Peanut Cultivars Including Tainan 11 and Tainan 12 (n = 6)

	free amino acid content (mg/g of protein)[a]		
	growing season		ANOVA
items	spring crop	fall crop	level
Asp	0.17 ± 0.02[a]	0.12 ± 0.01[b]	**
Thr	0.13 ± 0.05[a]	0.02 ± 0.01[b]	**
Ser	1.20 ± 0.24[b]	1.56 ± 0.17[a]	*
Glu	2.13 ± 0.17[a]	2.10 ± 0.13[a]	−
Pro	0.37 ± 0.09[a]	0.35 ± 0.06[a]	−
Gly	0.29 ± 0.19[a]	0.09 ± 0.03[a]	−
Ala	0.81 ± 0.23[a]	0.59 ± 0.14[a]	−
Cys	0.21 ± 0.19[a]	0.10 ± 0.03[a]	−
Val	0.72 ± 0.35[a]	0.39 ± 0.09[a]	−
Met	0.50 ± 0.49[a]	0.22 ± 0.20[a]	−
Ile	0.76 ± 0.20[a]	0.41 ± 0.23[b]	*
Leu	0.28 ± 0.15[b]	0.62 ± 0.18[a]	*
Tyr	0.72 ± 0.25[a]	0.21 ± 0.11[b]	**
Phe	1.04 ± 0.31[a]	0.81 ± 0.30[a]	−
His	0.20 ± 0.05[a]	0.25 ± 0.04[a]	−
Lys	0.05 ± 0.02[b]	0.20 ± 0.07[a]	**
Arg	0.43 ± 0.13[a]	0.38 ± 0.17[a]	−
total	10.01	8.42	
T[b]	3.54	3.28	
AT[b]	1.33	0.81	
T:AT[b]	2.88	4.05	

[a] Mean of determinations with standard deviation in the same row not followed by the same superscript letter are significantly different ($p < 0.05$) as analyzed by Student's t test. ANOVA levels: "−" indicates insignificant ($p > 0.05$); "*" indicates significant ($p < 0.05$); "**" indicates very significant ($p < 0.01$). [b] T, typical roasted flavor precursors; AT, atypical roasted flavor precursors; T:AT, ratio of sum of T and sum of AT.

glutamic acid, asparagine, glutamine, phenylalanine, and histidine as typical precursors (T) and threonine, lysine, tyrosine, and arginine as atypical precursors (AT). The T:AT ratio could be used as a potency indicator in the prediction of peanutty flavor formation after roasting (Pattee et al., 1982). Between the kernels of Spring and Fall crops, the concentrations of each individual typical and atypical flavor precursors varied. However, as an overall result, the T:AT ratio was 2.88 and 4.05 for Spring and Fall crops, respectively. This result indicates that kernels of Fall crops may have a higher potential than kernels of Spring crops to produce typical peanut flavor after roasting.

Sucrose contents and fatty acid compositions of peanut kernels of Spring and Fall crops are shown in Table 2. In comparison, the sucrose content was significantly higher in the kernels of Spring crops than in Fall crops ($p < 0.05$). The fatty acid composition also varied significantly between crops depending upon the nature of each constituent fatty acid. Significantly higher fatty acid contents of 18:0, 18:1, 20:0, and 22:0 were observed in the kernels of Spring crops than of Fall crops. Yearly, seasonal, climate condition, soil moisture content during maturation, and temperature variation in addition to genotype are possible causes affecting the fatty acid composition of peanut kernels (Worthington and Hammons, 1971; Worthington et al., 1972). The ratio of the contents of oleic acid and linoleic acid (O:L) was proposed as a reference in the prediction of product shelf life (Young et al., 1974; Worthington et al., 1972). Among Spring and Fall crops, O:L in Spring crops was higher than that in Fall crops. This was in agreement with a previous observation achieved through a consecutive 3-year study (Chiou et al., 1995) in which O:L is higher in the oils of Spring crops than that of Fall crops.

Table 2. Analysis of Variance (ANOVA) of Sucrose, Fatty Acid, and Headspace Volatile Contents between the Kernels of Spring and Fall Crops of Two Spanish Peanut Cultivars Including Tainan 11 and Tainan 12 (n = 6)

	sucrose content (mg/g of defatted meal)[a]		
	growing season		ANOVA
items	spring crop	fall crop	level
	75.6 ± 0.31[a]	61.4 ± 5.5[b]	*
fatty acid content (%, weight percentage)[a]			
16:0	10.9 ± 0.1[a]	11.0 ± 0.2[a]	−
18:0	4.3 ± 0.1[a]	3.4 ± 0.5[b]	**
18:1	40.6 ± 0.5[a]	37.2 ± 0.3[b]	**
18:2	35.1 ± 0.4[b]	40.0 ± 0.2[a]	**
18:3	0.04 ± 0.01[b]	0.08 ± 0.01[a]	**
20:0	2.0 ± 0.1[a]	1.6 ± 0.1[b]	**
20:1	0.9 ± 0.1[b]	1.1 ± 0.1[a]	**
22:0	4.2 ± 0.1[a]	3.5 ± 0.1[b]	**
24:0	1.4 ± 0.1[b]	1.5 ± 0.1[a]	*
O:L[b]	1.16	0.93	
headspace volatile quantity[a]			
total volatile, relative intensity	2.40 ± 0.31[a]	1.89 ± 0.34[a]	−
sulfur volatile, relative intensity	8.65 ± 0.98[a]	4.00 ± 1.46[b]	**

[a] Mean of determinations with standard deviation in the same row not followed by the same superscript letter are significantly different ($p < 0.05$) as analyzed by Student's t test. ANOVA levels: "−" indicates insignificant ($p > 0.05$); "*" indicates significant ($p < 0.05$); "**" indicates very significant ($p < 0.01$). [b] O:L, ratio of oleic acid content and linoleic acid content.

Pyrazine Compounds and Roasted Peanutty Flavor Formation. Pyrazine compounds generated during roasting of peanut kernels are recognized as the prime contributors of peanut flavor (Mason et al., 1966; Walradt et al., 1971; Buckholz et al., 1980; Ho et al., 1982; Pyrazine Specialties Inc., 1988). In this study, quantitation of pyrazine compounds as an index to evaluate the roasted flavor quality of peanut kernels of both crops was attempted. Pyrazine compounds in oils extracted from the roasted peanut kernels of Spring and Fall crops are shown in Table 3. In general, most pyrazine contents were higher in the oils prepared from Fall crops than the oils of Spring crops. For comparison of each individual pyrazine compound, 2-methyl, 2,5-dimethyl, 2-ethyl, 2,3-dimethyl, 2-ethyl-6-methyl, 2-ethyl-5-methyl, trimethyl, 2-ethyl-3,5-dimethyl, 3-ethyl-2,5-dimethyl, 2-ethyl-6-methyl, and dimethyl-2-vinyl pyrazine contents were significantly higher in Fall crops than those of Spring crops. Total pyrazine contents for Spring and Fall crops were 567.6 and 1012.6 ppm, respectively, when examining the sum of detected pyrazines. According to a pyrazine reference chart, 2-methyl, 2,5-dimethyl, 2-ethyl-5-(or 6-)methyl, trimethyl, 2-ethyl-3,5-dimethyl, and 3-ethyl-2,5-dimethyl pyrazines are characterized as the characteristic odors of roasted peanut or roasted nuts (Pyrazine Specialties Inc., 1988). Among those compounds obtained in this study, concentrations of 2-methyl, 2,5-dimethyl, 2-ethyl-5-methyl, 2-ethyl-5-methyl, trimethyl, 2-ethyl-3,5-dimethyl, and 3-ethyl-2,5-dimethyl were significantly higher in the roasted kernels of Fall crops than those of Spring crops. Based on the quantities of pyrazine compounds, particularly those characteristic odors, peanut kernels of Fall crops were richer than were

Table 3. Analysis of Variance (ANOVA) of the Contents of Pyrazine Compounds Extracted from the Roasted Kernels of Spring and Fall Crops of Two Spanish Peanut Cultivars Including Tainan 11 and Tainan 12 ($n = 4$)

pyrazines[a]	growing season: spring crop	growing season: fall crop	ANOVA level
2-methyl pyrazine, ppb	46.0 ± 14.1[b]	90.0 ± 8.8[a]	**
2,5-dimethyl pyrazine, ppb	196.3 ± 69.9[b]	351.1 ± 14.1[a]	*
2-ethyl pyrazine, ppb	21.4 ± 5.5[b]	34.3 ± 2.9[a]	**
2,3-dimethyl pyrazine, ppb	6.8 ± 1.8[b]	15.0 ± 1.9[a]	**
2-ethyl-6-methyl pyrazine, ppb	19.3 ± 5.9[b]	36.7 ± 1.9[a]	*
2-ethyl-5-methyl pyrazine, ppb	74.0 ± 16.9[b]	132.9 ± 20.3[a]	**
trimethyl pyrazine, ppb	62.7 ± 14.1[b]	131.9 ± 38.4[a]	*
2-ethyl-3,5-dimethyl pyrazine, ppb	41.8 ± 10.6[b]	77.1 ± 21.0[a]	*
3-ethyl-2,5-dimethyl pyrazine, ppb	31.7 ± 8.6[b]	51.6 ± 4.8[a]	**
2-ethyl-6-methyl pyrazine, ppb	7.4 ± 1.7[b]	14.4 ± 2.4[a]	**
isopropyl pyrazine, ppb	19.1 ± 4.1[a]	38.3 ± 17.4[a]	−
3,5-diethyl-2-methyl pyrazine, ppb	19.3 ± 5.4[a]	21.0 ± 3.8[a]	−
dimethyl-2-vinyl pyrazine, ppb	18.1 ± 8.7[b]	39.0 ± 9.3[a]	*
5-allyl-2,3-dimethyl pyrazine, ppb	7.0 ± 3.4[a]	12.0 ± 3.1[a]	−
2-isopropyl-3-methyl pyrazine, ppb	4.3 ± 6.1[a]	6.4 ± 0.6[a]	−
total pyrazines, ppb	567.6 ± 172.9[b]	1012.6 ± 138.3[a]	**

[a] Mean of determinations with standard deviation in the same row not followed by the same superscript letter being significantly different ($p < 0.05$) as analyzed by Student's t test. ANOVA levels: "−" indicates insignificant ($p > 0.05$); "*" indicates significant ($p < 0.05$).

kernels of Spring crops. This was supportive of the consumer concept indicating that peanut kernels of Fall crops are somewhat richer in flavor than are kernels of Spring crops.

Various and extensive pyrazine compounds can be formed through amino acids and sugars in model systems and peanut kernels (Koehler et al., 1969; Mason et al., 1966; Walradt et al., 1971; Shibamoto and Bernhard, 1976, 1977; Buckholz et al., 1980; Ho et al., 1982; Huang et al., 1989). As a common prediction, the more free amino acid contents in peanut kernels should produce the higher contents of volatile compounds after roasting. In this study, a higher total free amino acid content in the kernels of Spring crops than Fall crops (Table 1) did not subsequently produce more pyrazine compounds after roasting. This implies that pyrazine compounds are formed through specific reactants and under specified conditions. In comparisons of the sum of the concentration of the typical (T) and atypical (AT) flavor precursors and the T:AT ratio shown in Table 1, both typical and atypical flavor precursor contents were higher in Spring crops than Fall crops, and yet resulted in a lower T:AT ratio for the former than the latter. For more specific comparisons of the typical and atypical amino acids between the kernels of Spring and Fall crops, threonine and tyrosine contents were atypical flavor precursors and higher in Spring crops than Fall crops which was the main reason for a lower T:AT ratio in Spring crops. Pattee et al. (1982) have suggested the T:AT ratio as an index of the potential for good roasted flavor quality. This suggestion was further supported by the observation that a higher T:AT ratio was linked with a higher content of the characteristic pyrazine compounds produced in the kernels of Fall crops than those of Spring crops (Tables 1 and 3). On the other hand, the sucrose content might also affect the formation of pyrazine compounds. In a model system (Koehler and Odel, 1970), a 3-fold increase of glucose as a reactant resulted in a 10-fold decrease of 2-methyl pyrazine and a 125-fold decrease of dimethyl pyrazine formation. The higher sucrose content in the kernels of Spring crops (Table 1) might inhibit pyrazine formation during roasting.

Total and sulfur headspace volatile contents of the peanut kernels of Spring and Fall crops are shown in Table 2. In comparison of the total volatile contents between Spring and Fall crops, the difference was insignificant ($p > 0.05$). However, the sulfur volatile content was significantly higher ($p < 0.05$) in Spring crops than in Fall crops. When a comparison was made between the results obtained in headspace analysis and pyrazine compound quantitation, a higher sulfur volatile content and a lower pyrazine content were observed in the kernels of Spring crops than in the kernels of Fall crops (Tables 2 and 3). The lower roasted flavor evaluation in the kernels of Spring crops might be attributed to the possibility that more atypical flavors have been produced to mask normal flavor performance compared to kernels of Fall crops. Headspace volatile analysis is an efficient means to evaluate the flavor quality of raw peanut kernels (Young and Hovis, 1990). In particular, in Taiwan, the late growing period for Spring crops is occasionally encountered with a monsoon season, and peanut pods in wet or even water-soaked soil condition might have caused their chemical composition to change and consequently influenced headspace volatile and roasted flavor performance.

In conclusion, peanut kernel compositions including quantities of free amino acids, sucrose, fatty acids, headspace volatiles, and roasted pyrazine compounds varied as affected by growing season. Based on the T:AT ratio obtained from the analysis of free amino acids, T:AT was higher in Fall crops than in Spring crops. In headspace volatile analysis, total sulfur content was higher in the kernels of Spring crops than in the kernels of Fall crops. Higher contents of the peanut flavor-related pyrazine compounds produced after roasting in the kernels of Fall crops were in agreement with the general consumer concept indicating that kernels of Fall crops are richer in peanut flavor than are kernels of Spring crops.

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