Compositional Characterization of Peanut Kernels after Subjection to Various Germination Times

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Sound and mature peanut kernels of Tainan 9, Tainan 11, and Tainan 12 (Spanish cultivars) were soaked with deionized water for 8 h and incubated for up to 96 h in a growth chamber programmed with a 12-h day/night cycle at 29 ± 1 and 23 ± 1 °C, respectively. On the basis of emergence and elongation of seed radicle, Tainan 12 germinated slightly more rapidly than the others, followed in order by Tainan 11 and Tainan 9. Moisture content of the kernels increased and their dry solid contents decreased with time of incubation. During germination, protein contents decreased very slightly, while their SDS−PAGE patterns varied quantitatively rather than qualitatively. Sucrose content and lipoxygenase activity decreased in the early stages of incubation. Total free amino acid and free fatty acid contents increased with time of incubation. Rapid changes of free amino acid composition were observed even at the initial 8 h of incubation. Greater than 5-fold increases over original levels in threonine, serine, proline, glycine, tyrosine, histidine, and arginine contents were observed after 72 h of germination. Fatty acid composition varied in a limited range, while small amounts of linolenic acid (18:3) were present in kernels in the latter stages of germination.

Keywords: *Peanut; germination; free amino acid, fatty acid; lipoxygenase; protein; sucrose*

INTRODUCTION

Seed germination is a primary step to generate a new plant. During germination, a series of active and complex biochemical and physiological reactions is taking place, which results in extensive changes in composition and/or morphology. Intensive investigations on compositional changes of plant seeds during germination are important because of the necessity of understanding the compositional changes and relevant functions from the viewpoint of plant science. When the seeds are destined for food use, an understanding of the compositional changes resulting from germination in relation to food quality is also important. Since some genotypes of peanut, such as Spanish peanuts, do not have dormant characteristics, their kernels may germinate in pods during the late planting period in a drought season or in windrows after harvest if there is a sudden rainfall. Seed germination may be initiated and proceed to various extents. Slight germination may cease when water is not available and may not necessarily result in an obvious change in kernel appearance (morphology). However, slight germination should result in compositional changes. Thus, the quality of the peanut seeds as affected by various extents of germination is of interest to peanut scientists and is also of concern to peanut growers, processors, and consumers.

On the other hand, the potential of raw peanut kernels to generate a unique "peanutty" flavor during roasting is one of the most important items considered in the quality evaluation of raw peanut kernels. 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. Since slightly germinated kernels may be visibly sound in appearance, they can hardly be sorted in the routine inspections. However, the chemical composition, particularly with regard to some flavor-related precursors, might have changed to a significant extent and affected the flavor quality of roasted products. In this study, peanut kernels of three commonly grown cultivars were subjected to a series of germination times. Compositional changes of the peanut kernels during germination were extensively investigated. The changes resulting from seed germination in relation to possible quality attributes, particularly changes of free amino acids, from the viewpoint of food processing were addressed.

MATERIALS AND METHODS

Peanut Kernels. Three commonly grown Spanish cultivars, i.e., Tainan 9, Tainan 11, and Tainan 12, were planted from late February to late June 1996. Triplicate experiments were conducted. Peanuts were harvested 70 days after flowering and sun-dried on a cement slab. The dried pods were shelled manually, and pods containing at least one shriveled kernel were designated immature and separated. Sound kernels from mature pods were sieved (1.92 × 0.6 cm, U.S. No. 1 standard) to collect U.S. No. 1 kernels for use in this study.

Germination of Peanut Kernels. A series of germination times including 0, 8, 24, 48, 72, and 96 h were used. For each

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germination time, 36 kernels from each cultivar (12 kernels for each of the triplicate experiments) were weighed on a single-kernel basis and placed in a well of a series of cell culture trays (4 × 6, polystyrene, Corning cell wells, Corning Co.). Each well after deposition of a weighed peanut kernel was replenished with 2 mL of deionized water, covered with a lid, and incubated at 8 a.m. in a growth chamber programmed with a 12-h day/night cycle at 29 ± 1 °C with 8000 lux of light intensity and at 23 ± 1 °C for day and night periods, respectively. The kernels were washed and rinsed with deionized water twice at 8, 24, 48, and 72 h of incubation. For each germination period, 36 kernels of a cultivar were removed from the chamber and each kernel was weighed separately and freeze-dried (Lab Conco Freeze-Drier 18). Changes of moisture and dry solid contents of the kernels during germination on a single kernel basis were determined after freeze-drying. Freeze-dried kernels were deskinned and distributed into three sublots (each containing 12 kernels) and subjected to compositional analyses.

Sucrose, Free Amino Acid, and Protein Analyses. Freeze-dried and deskinned kernels were hydraulically pressed (150−170 kg/cm^2) to extract peanut oil and to prepare partially defatted peanut meals. The partially defatted meals were further defatted with *n*-hexane at −20 °C to prepare *n*-hexane-defatted flours and subjected to methanol/chloroform/water (MCW) extraction (Rodriguez et al., 1989) and analyses of sucrose content and free amino acid composition following the procedure reported by Chiou et al. (1991a). The nitrogen content of the *n*-hexane-defatted peanut flour was determined according to the Kjeldahl method (AOAC, 1984) and used for crude protein content estimation (N × 5.46).

Sodium dodecyl sulfate−polyacrylamide gel electrophoresis (SDS−PAGE) was applied for analysis of peanut protein patterns in kernels during germination. Proteins were extracted from *n*-hexane-defatted peanut flours at the same basis of protein content determined previously and subjected to SDS−PAGE analysis according to the procedures of Laemmli (1970) and Chiou et al. (1991a).

Lipid and Lipoxygenase Activity Analyses. The hydraulically pressed oils were deposited in brown vials, cap sealed, and stored at −25 °C until used for further analyses. For determination of free fatty acid content in the extracted oils, a colorimetric (copper soap) method was followed with minor modification (Koops and Klomp, 1977; Shipe et al., 1980; Chiou et al., 1993). Fifty milligrams of oil was deposited in a centrifuge tube (Nalgene 3114-0010, Nalge Co., Rochester, NY) and mixed with 0.1 mL of HCl (0.1 M) and 5 mL of chloroform/heptane/methanol (CHM, 49:49:2, v/v/v) and 2 mL of the copper reagent. The capped tube was shaken for 30 min at room temperature with a vortex (1400 rpm, IKA-Vibrax-VXR, Janke & Kumkel GmbH & Co. KG, IKA Labortechnik, Staufen, Germany) and then centrifuged at 8500*g* at 20 °C for 10 min. One milliliter of the solvent layer was withdrawn and mixed with 4 mL of CHM and 0.1 mL of the color reagent. The absorbance at 440 nm was determined with a spectrophotometer. Linoleic acid was used as a reference for constructing a standard curve, and the free fatty acid content was expressed as milligrams of linoleic acid per gram of oil.

For analysis of fatty acid composition, each peanut oil was subjected to methylation and gas chromatography using the procedure of Alonso and Juarez (1986) with minor modification. Approximately 15 mg of oil was deposited in an Eppendorf tube and mixed with 100 μL of 14% tetramethylammonium hydroxide (w/v) in methanol. The tube was vigorously shaken for 1 min with a vortex shaker at room temperature. One milliliter of *n*-hexane was added and shaken for an additional 1 min before 0.5 mL of deionized water was added to stop the reaction. The hexane layer was withdrawn and mixed with anhydrous sodium sulfate for dehydration, from which 1 μL was injected onto a gas chromatography for fatty acid composition analysis. A gas chromatograph (HP 5890 Series II, Hewlett-Packard) using a capillary column (HP Innowax, 30 m × 0.25 mm and 0.15 mm film thickness) equipped with a flame ionization detector (FID) was used. Carrier gas was helium and controlled at a liner velocity of 40 cm/s and a split ratio of 30:1. Flow rates of hydrogen and air were 30 and 300 mL/min, respectively. Column oven temperature was held at 180 °C for 1 min, linearly increased to 225 °C at 25 °C/min, further increased to 260 °C at 5 °C/min, and held for an additional 5 min. The injector and detector temperatures were 250 and 270 °C, respectively. The component fatty acids were identified by a GC/MS. A gas chromatograph (HP 5890 Series II) was operated in the same manner as that for analyses of peanut oils, and the results were subjected to mass analysis. A mass selective detector (HP 5972A) was conducted (transfer-line temperature, 265 °C; mass range, 10−700; and ion voltage, 70 eV), and compounds were identified by a data library (Wiley 275K, HP).

For lipoxygenase activity determination, the procedure of substrate solution preparation reported by Chen and Whitaker (1986) and Chiou et al. (1991b) was followed, and the procedure for crude enzyme solution preparation was followed with minor modification. For lipoxygenase solution extraction, 50 mg of *n*-hexane-defatted flour was deposited in a 5-mL screw-capped test tube and mixed with 5 mL of sodium phosphate buffer (pH 7.0, 0.2 M containing 5% NaCl at 4 °C). Each test tube was nitrogen flushed, cap sealed, and shaken at 800 rpm with a vortex (IKA-Vibrax-VXR) for 30 min at 4 °C. One milliliter of the suspension was withdrawn in an Eppendorf tube and centrifuged at 6000*g* for 30 s (Force 7 Microcentrifuge, Denver Instrument Co. Asia Ltd., Hong Kong), and the supernatant was used as crude lipoxygenase solution. A 0.2-mL aliquot of the enzyme solution was mixed with 2.3 mL of phosphate buffer (pH 7.0, 0.2 M at 25 °C) and 0.5 mL of substrate solution in a quartz cuvette. The absorbance (234 nm) at 25 °C was spectrophotometrically determined using a time-scanning mode (Hitachi U-2000). A unit of enzyme activity was defined as the amount of enzyme that produced a change in optical density of 1.0/min at 234 nm. The specific lipoxygenase activity was determined by dividing the total enzyme activity units by the protein content expressed as absorbance unit increments per minute per gram of protein in the *n*-hexane-defatted flour used for enzyme extraction.

Statistics. Triplicate experiments were conducted. ANOVA was applied to analyze the variance in determinations of moisture, retained solid, protein, sucrose, and free fatty acid contents and specific lipoxygenase activity for each peanut cultivar and in the consolidated free amino acid and fatty acid compositions for the three test Spanish cultivars as affected by germination time. The analysis was followed by each-pair comparisons through Student's *t* test using JMP software (SAS Institute Inc.) for statistical visualization.

RESULTS AND DISCUSSION

Photographs of kernels of Tainan 9, Tainan 11, and Tainan 12 subjected to various germination times including 0, 8, 24, 48, 72, and 96 h are shown in Figure 1. Emergence and elongation of seed radicles of the kernels during germination could be used as an index of germination rapidity. In comparison, kernels of Tainan 12 germinated slightly more rapidly than did kernels of the others, followed in order by kernels of Tainan 11 and Tainan 9.

Changes of moisture and freeze-dried solid contents of the kernels during germination are presented in Table 1. Average moisture content of the kernels increased rapidly from approximately 3.2 to 32% (wet basis) in the first 8 h of incubation when kernels were soaked with deionized water for imbibition and then increased gradually to approximately 46% with further incubation. After 24 h of incubation, freeze-dried solid content of the kernels decreased slightly with time. Cherry (1963) reported that the dry weight of peanut seeds slightly decreased in the first 5 days of germination at 30 °C under a humid atmosphere condition. It is apparent that some dry solid matter of peanut kernels was consumed for seed germination.

Peanut kernels after subjection to various germination times were freeze-dried, deskinned, hydraulically

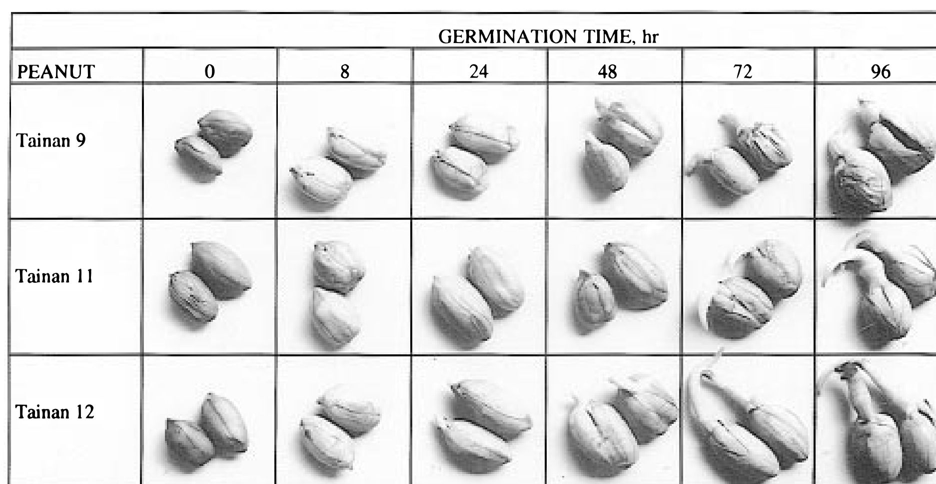

Figure 1. Photographs of peanut kernels of Tainan 9, Tainan 11, and Tainan 12 subjected to various germination times up to 96 h.

Table 1. Moisture, Dry Solid, Crude Protein, Sucrose, and Free Fatty Acid Contents and Lipoxygenase Activity of ANOVA of Peanut Kernels of Tainan 9, Tainan 11, and Tainan 12 Subjected to Various Germination Times

peanut	time of germination						ANOVA level[a]
	0 h	8 h	24 h	48 h	72 h	96 h	
Moisture Content, % (Wet Basis) ($n = 36$)							
Tainan 9	3.3^{e}	32.8^{d}	37.1^{c}	42.3^{b}	45.6^{ab}	46.1^{a}	**
Tainan 11	3.0^{e}	33.8^{d}	39.5^{c}	43.0^{b}	49.3^{a}	45.9^{ab}	**
Tainan 12	3.2^{e}	31.5^{d}	36.8^{c}	40.8^{b}	46.1^{a}	46.2^{a}	**
Retained Freeze-Dried Solid Content,[b] % ($n = 36$)							
Tainan 9	100^{a}	100^{a}	100^{a}	99.8^{bc}	99.3^{bc}	98.8^{c}	*
Tainan 11	100^{a}	100^{a}	100^{a}	99.7^{ab}	99.5^{ab}	99.3^{b}	*
Tainan 12	100^{a}	100^{a}	100^{a}	99.7^{a}	99.5^{ab}	99.2^{b}	–
Protein Content, g/100 g of *n*-Hexane-Defatted Flour ($n = 3$)							
Tainan 9	53.3^{b}	55.8^{a}	53.7^{b}	51.7^{bc}	50.0^{c}	51.7^{bc}	*
Tainan 11	52.8^{a}	52.8^{a}	53.0^{a}	51.4^{ab}	49.8^{b}	49.9^{b}	*
Tainan 12	53.8^{a}	51.8^{ab}	52.5^{a}	51.1^{ab}	52.9^{ab}	51.0^{b}	–
Sucrose Content, mg/g of *n*-Hexane-Defatted Flour ($n = 3$)							
Tainan 9	74.9^{a}	62.0^{ab}	49.1^{bc}	47.0^{c}	38.9^{c}	41.8^{c}	**
Tainan 11	63.1^{a}	54.6^{ab}	43.5^{b}	39.9^{b}	49.3^{ab}	60.4^{a}	*
Tainan 12	63.3^{ab}	62.1^{ab}	55.9^{b}	51.8^{ab}	55.2^{ab}	72.1^{a}	*
Free Fatty Acid Content, mg of FFA/g of Oil ($n = 3$)							
Tainan 9	1.26^{c}	4.66^{b}	1.53^{c}	7.73^{a}	9.83^{a}	9.84^{a}	**
Tainan 11	1.29^{c}	1.32^{c}	2.56^{c}	4.89^{b}	8.41^{a}	7.96^{a}	**
Tainan 12	2.36^{bc}	1.44^{c}	3.95^{b}	7.25^{a}	8.34^{a}	8.66^{a}	**
Lipoxygenase Activity, Units/g of Protein ($n = 3$)							
Tainan 9	126.8^{b}	129.8^{b}	134.2^{b}	140.1^{b}	96.8^{c}	159.4^{a}	**
Tainan 11	241.1^{a}	247.7^{a}	174.0^{b}	123.5^{c}	146.2^{bc}	153.6^{bc}	**
Tainan 12	165.4^{a}	119.4^{b}	110.1^{b}	130.0^{b}	115.0^{b}	128.6^{b}	*

[a] Mean values in the same row that are not followed by the same superscript letter are significantly different ($p < 0.05$) 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] Percentage determined in proportion to original freeze-dried solid content of the kernels before germination.

pressed to extract oil, and defatted with *n*-hexane to prepare defatted flours used for compositional analyses. Sucrose content in the *n*-hexane-defatted flours decreased in the early stages of germination and increased with further incubation (Table 1). For Tainan 11 and Tainan 12, sucrose contents decreased from 63.1 to 39.9 mg/g of defatted flour and from 63.3 to 51.8 mg/g of defatted flour in the initial 48 h of germination and increased to 60.4 and 72.1 mg/g of defatted flour after 96 h of incubation, respectively. Sucrose content of Tainan 9 decreased from 74.9 to 38.9 mg/g of defatted flour in 72 h and increased to 41.8 mg/g of the defatted flour at 96 h of incubation. Since Tainan 9 germinated more slowly than did the other two cultivars (Figure 1), changes of sucrose content seem to be closely related to the extent of progress of seed germination. Sucrose is one of the predominant storage carbohydrates in peanut seeds and serves as a major energy source for metabolism during germination (Basha, 1992; Nascimento et al., 1994; Vercelloti et al., 1995). Direct use of sucrose for energy consumption in the early stages of initiation of germination and metabolic regeneration from the other organic materials, such as fat (Beevers, 1961), might render a significant change of sucrose content in peanut kernels during germination.

During peanut germination, crude protein contents varied in a limited range as affected by peanut cultivar and time of incubation (Table 1). Since crude protein content was expressed on a dry solid basis and dry solid content of the kernels slightly decreased with time of germination, absolute protein contents in kernels also decreased very slightly during germination. This was in agreement with the observations that storage protein contents decreased slightly in the early stages of germination (Cherry 1963; Bagley et al., 1963). SDS–PAGE protein patterns (Figure 2) of the peanut proteins

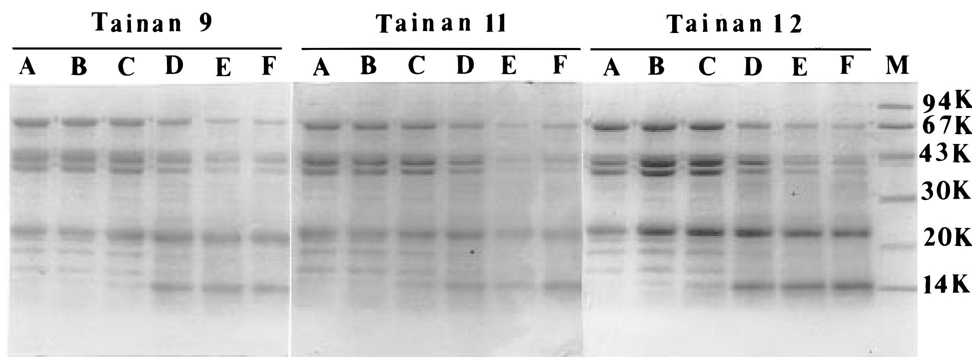

Figure 2. SDS–PAGE protein patterns of peanut proteins extracted from peanut kernels of Tainan 9, Tainan 11, and Tainan 12 subjected to various germination times up to 96 h: (A) 0 h; (B) 8 h; (C) 24 h; (D) 48 h; (E) 72 h; (F) 96 h; (M) standard protein markers.

extracted from peanut kernels after germination indicate that protein patterns changed quantitatively rather than qualitatively during germination. Similar protein patterns in the three test peanut kernels before germination were observed as they belong to the same Spanish cultivar (Bianchi-Hall et al., 1994). On the basis of the protein pattern changes, degradation of storage proteins during germination was observed. In general, major peanut storage proteins including conarachin with a molecular weight (MW) ca. 67 000 and arachins with a MW between 40 000 and 45 000 degraded, which was particularly obvious after 48 h of germination. Meanwhile, a small protein subunit with a MW ca. 14 000 was formed. Another protein subunit with a MW ca. 24 000 changed as affected by peanut cultivar and time of germination.

Changes of free fatty acid (FFA) content in the oils prepared from peanut kernels during germination as affected by germination were very significant (Table 1). In general, FFA contents increased significantly after 48 h of incubation. Specific lipoxygenase activity in the *n*-hexane-defatted flours of the test peanuts is also presented in Table 1. Before germination, the highest activity was observed in kernels of Tainan 11, followed by kernels of Tainan 12 and Tainan 9. During germination, specific lipoxygenase activity of Tainan 12 decreased at 8 h of incubation, that of Tainan 11 decreased at 24 h of incubation, and that of Tainan 9 decreased at 72 h of incubation. In accordance with germination progress of the three cultivars shown in Figure 1, decrease of specific lipoxygenase activity of the peanut kernels seems to be an indicator of germination rapidity. Lipoxygenase activity is related to dormancy breakdown of peanut seeds through creating precursors for ethylene production (Ketring and Pattee, 1985). However, the three peanuts tested in this study are Spanish cultivars, known as having no obvious dormant characteristics. The tendency to cause an early decrease in specific lipoxygenase activity in relation to difference of germination rapidity is worthy of further investigation.

Changes of free amino acid composition of peanut kernels of the three test cultivars during germination varied as functions of time of incubation and nature of individual amino acid (Table 2). All amino acid contents except alanine and cysteine contents varied very significantly ($p < 0.01$) during germination. Total free amino acid contents increased from 6.76 to 9.00 mg/g of protein in 8 h of incubation when peanut kernels were soaking in deionized water. In general, each individual amino acid increased its content at a specific interval of germination. Total free amino acid contents increased continuously up to 72 h of germination. Tremendous increases (more than 5-fold over the original levels) in threonine, serine, proline, glycine, tyrosine, histidine, and arginine contents were observed after 72 h of germination.

Table 2. Consolidated Data of Free Amino Acid Contents (Milligrams per Gram of Protein) of ANOVA of Peanut Kernels of Spanish Cultivars including Tainan 9, Tainan 11, and Tainan 12 Subjected to Germination for Various Times (*n* = 9)

amino acid	time of germination 0 h	8 h	24 h	48 h	72 h	96 h	ANOVA level[a]
Asp	0.22^{d}	0.21^{d}	0.44^{c}	0.56^{b}	0.67^{a}	0.66^{a}	**
Thr	0.10^{d}	0.19^{cd}	0.18^{d}	0.39^{bc}	0.71^{a}	0.53^{ab}	**
Ser	0.88^{c}	1.13^{c}	1.70^{c}	3.82^{b}	6.52^{a}	5.73^{a}	**
Glu	1.93^{c}	1.49^{d}	2.19^{c}	2.83^{b}	3.29^{a}	3.05^{ab}	**
Pro	0.37^{c}	0.28^{c}	0.72^{c}	2.44^{b}	10.53^{a}	10.84^{a}	**
Gly	0.09^{d}	0.08^{d}	0.09^{d}	8.05^{c}	17.60^{b}	19.65^{a}	**
Ala	0.69^{a}	0.69^{a}	0.86^{a}	0.67^{a}	0.92^{a}	0.95^{a}	–
Cys	0.30^{a}	0.29^{a}	0.27^{a}	0.52^{a}	0.39^{a}	0.27^{a}	–
Val	0.36^{d}	0.43^{cd}	0.58^{c}	0.97^{b}	1.44^{a}	1.32^{a}	**
Met	0.11^{c}	0.12^{c}	0.25^{b}	0.41^{a}	0.43^{a}	0.38^{a}	**
Ile	0.26^{c}	0.32^{c}	0.44^{b}	0.70^{a}	0.76^{a}	0.64^{a}	**
Leu	0.24^{c}	0.40^{bc}	0.57^{b}	0.88^{a}	0.84^{a}	0.82^{a}	**
Tyr	0.27^{d}	0.60^{cd}	0.80^{c}	1.76^{b}	2.33^{a}	2.01^{ab}	**
Phe	0.54^{c}	1.06^{bc}	1.09^{bc}	1.75^{ab}	2.30^{a}	2.27^{a}	**
His	0.11^{d}	1.38^{b}	0.86^{c}	1.41^{b}	2.02^{a}	1.82^{a}	**
Lys	0.08^{b}	0.10^{b}	0.17^{b}	0.30^{a}	0.39^{a}	0.34^{a}	**
Arg	0.21^{c}	0.23^{c}	0.39^{c}	1.62^{b}	3.96^{a}	3.52^{a}	**
total	6.76	9.00	11.60	29.08	55.10	54.80	
T[b]	2.80	4.14	4.68	6.55	8.28	7.80	
AT[b]	0.66	1.12	1.54	4.07	7.39	6.40	
T-AT[b]	4.24	3.70	3.04	1.61	1.12	1.22	

[a] Mean values in the same row that are not followed by the same superscript letter are significantly different ($p < 0.05$) 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.

According to the data shown in Table 2, both typical (T) and atypical (AT) precursor contents (Pattee et al., 1982) increased significantly during germination. As a result, T-AT ratios decreased with time of germination and might be negative for flavor production after roasting. Since free amino acid composition changed rather rapidly even in the initial 8 h during soaking in water for imbibition, peanut flavor quality must be eventually affected. It seems that changes of free amino acid composition take place simultaneously when peanut kernels are rehydrated and germination is initiated. When peanut kernels were subjected to a short period of germination and dried, they were still visibly sound in appearance and could not reasonably be sorted in the

Table 3. Consolidated Data of Fatty Acid Contents (Percent) of ANOVA of Peanut Kernels of Spanish Cultivars including Tainan 9, Tainan 11, and Tainan 12 Subjected to Germination for Various Times ($n = 9$)

fatty acid	time of germination						ANOVA level[a]
	0 h	8 h	24 h	48 h	72 h	96 h	
16:0	16.0[a]	16.8[a]	15.7[a]	15.6[a]	16.3[a]	18.8[a]	–
18:0	4.0[a]	4.3[a]	3.8[a]	3.9[a]	3.7[a]	4.0[a]	–
18:1	40.4[a]	40.4[a]	41.6[a]	41.5[a]	41.1[a]	40.0[a]	–
18:2	35.6[a]	34.4[ab]	35.1[ab]	35.3[a]	34.0[b]	34.9[ab]	–
18:3	0[c]	0[c]	0[c]	0.1[bc]	0.2[ab]	0.2[a]	–
20:0	1.1[ab]	1.1[a]	0.8[b]	1.0[ab]	1.0[ab]	1.0[ab]	–
20:1	0.5[a]	0.6[a]	0.5[a]	0.5[a]	0.5[a]	0.5[a]	–
22:0	1.2[a]	1.1[a]	1.2[a]	1.1[a]	1.2[a]	1.1[a]	–
24:0	0.4[a]	0.4[a]	0.4[a]	0.4[a]	0.4[a]	0.4[a]	–

[a] Mean values in the same row that are not followed by the same superscript letter are significantly different ($p < 0.05$) analyzed by Student's t test. ANOVA levels: –, indicates insignificant ($p > 0.05$); *, indicates significant ($p < 0.05$); **, indicates very significant ($p < 0.01$).

routine inspections, yet they were detrimental to peanut flavor quality according the decrease of T-AT ratio. Particularly for the peanut cultivars with insignificant dormancy, such as Spanish cultivars, the probability to initiate germination of the peanut kernels in pods during the later planting period in drought conditions or in windrows after harvesting due to unexpected rainfall should be of concern.

Fatty acid compositions of peanut oils extracted from peanut kernels of the three test cultivars subjected to various germination times are shown in Table 3. On the basis of ANOVA, changes of all fatty acids were insignificant during germination. However, linoleic acid (18:2), linolenic acid (18:3), and ecosenoic acid (20:0) contents changed significantly in a specific period of germination. Small amounts of linolenic acid (18:3) were present in peanut seeds in the latter stages of germination.

In conclusion, active and complex biochemical reactions in peanut kernels are initiated and proceed during germination, resulting in significant compositional changes. In nature, an integrated assembly of the metabolic activities is aimed at the target of obtaining a successful germination and a healthy seedling. However, when the seeds are destined for food use, their food quality could be enhanced or decreased through germination depending on whatever the characteristics that are emphasized and pursued.

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