Characterization of Peanut Kernels As Affected by Harvest Date and Drying Practices

Robin Y.-Y. Chiou,*,† Chii-Dong Liu,‡ Ching-Ping Liu,‡ Sophia Ferng,† and Rong-Tsuen Tsai†

Department of Food Industry and Department of Agronomy, National Chiayi Institute of Agriculture, Chiayi, Taiwan 60083, Republic of China

Peanuts (Tainan no. 9 and no. 11, Spanish cv.) were harvested at 50, 60, 70, and 80 days after flowering. The peanut pods were removed from the vines and sun-dried or oven-dried or not removed from vines and sun-dried to a moisture content below 9%. The average size and weight percentage of the sized kernels (U.S. no. 1 shelled Spanish) increased as the maturity increased. Total α-amino nitrogen, conarachin, total soluble carbohydrate, glucose, and sucrose contents decreased significantly as the kernels matured. The kernel color (*L* value) during roasting increased with maturity, indicating that the average maturity of the sized kernels increased with an increase in growing period. At the same harvest date, various drying practices resulted in a variation in chemical composition and color of the kernels during roasting.

INTRODUCTION

The influence of the curing temperature and the maturity of harvested peanuts on the quality of peanut products has been extensively studied by numerous investigators. Pattee et al. (1965) reported that acetaldehyde, ethanol, and ethyl acetate were among the volatile compounds present in high-temperature-cured peanuts that might indicate flavor deterioration. Thomas et al. (1968) observed that peanuts cured at 49 °C in a forced draft drying bin were significantly inferior in quality to both bag-cured and field-cured nuts. Peanut products produced from mature kernels were superior in quality to products made from immature and undeveloped kernels.

Singleton et al. (1971) cured peanuts at temperatures ranging from 22 to 50 °C and showed that an increase in acetaldehyde content, which resulted in poorer sensory quality, was detected with each increase in curing temperature. Young (1973) reported that significant increases in carbonyls occurred as the curing temperature increased. Sanders et al. (1989a,b) reported that intensity ratings for roasted peanutty and sweet aromatic flavor of peanuts roasted to the same Hunter *L* or roasted for the same time were lowest and ratings for fruit fermented, painty, sour, and bitter were highest for immature peanuts cured at the higher temperatures. In general, high-temperature curing of peanuts results in off-flavor which is more pronounced in immature kernels.

With respect to changes in chemical composition of peanut kernels, most studies have been directed toward determining the influence of maturity rather than curing temperature (Young et al., 1974; Pattee et al., 1974; Basha et al., 1976; Amaya-Farfan et al., 1978; Sanders, 1980; Sanders et al., 1982; Rodriguez et al., 1989). Sanders et al. (1989a) investigated the interaction of maturity and curing temperature on descriptive flavor attributes of peanuts and reported that intensity ratings of roasted peanutty and sweet aromatic were lowest and ratings for fruit fermented, painty, sour, and bitter were highest for immature peanuts cured at the higher temperature. However, the interaction of maturity and drying temperature on the indigenous changes of chemical composition has not been intensively investigated. In the literature, specific studies addressing changes of chemical composition and quality as influenced by practical drying means are limited.

In this study, the objective was to investigate the combined effects of harvest date (maturity) and drying practice (drying procedures) on the average size and weight percentage of the sized peanut kernels (U.S. no. 1 shelled Spanish). The effects on the compositional changes of the flavor-related compounds and color performance during roasting were extended.

MATERIALS AND METHODS

Peanuts. Tainan no. 9 and Tainan no. 11 peanuts were planted in the field from February 20 to July 15, 1990. A randomized complete block design (RCBD) was followed. Three replications were randomly distributed in the experimental field plot, and peanuts were harvested 50, 60, 70, and 80 days after flowering. For each treatment, 7 m^2 (5 m × 1.4 m) of land were used and peanuts were planted at distances of 10-cm intrarow and 35-cm interrow.

At harvest, 50 peanut plants were dug randomly from each test area and subjected to three drying (curing) procedures: the pods were removed from the vines immediately after digging and sun-dried (30–35 °C [ambient maximum day temperature], 15 000–80 000 lux of light intensity, and 7 h per day) on a cement slab; the pods were left on the vines and sun-dried as described above for 6 days on a cement slab; and the pods were removed from vines immediately after digging and artificially dried in a forced draft drying bin controlled at 40 °C.

The dried pods were hand shelled, and kernels were size graded into U.S. no. 1 (19.05-mm × 5.95-mm slots) and others. The average weight and moisture content of the no. 1 kernels were determined. For moisture content determination, approximately 10 kernels from each sized sample were ground into meal using a cyclone mill. Then 2 g of meal was weighed and dried at 105 °C until a constant weight was reached. Since the moisture content of the kernels varied greatly among treatments, the comparison of size (wt/kernel) was expressed as dry solid content. The no. 1 fractions were stored at −18 °C until subjected to analyses. All determinations in this study were made using U.S. no. 1 sized kernels.

Compositional Analyses. The peanut kernels were freeze-dried (Lab Conco Freeze Drier, Model 80). Skins and hearts were removed, and cotyledons were ground with a cyclone mill (1 mm) and defatted with precooled *n*-hexane (−20 °C) (Chiou

* Author to whom correspondence should be addressed.
† Department of Food Industry.
‡ Department of Agronomy.

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Table I. ANOVA of Peanut Kernel Composition and Roasted Kernel Color of Tainan No. 9 Peanut Kernels at Various Maturity Stages Which Were Subjected to Various Drying Practices

	source of variance (degrees of freedom)					
item	block (2)	harvest date (3)	main error (6)	drying practice (2)	interaction (6)	minor error (16)
moisture content	0.04	10.65**	1.34	7.47**	5.68**	2.18
kernel weight	0.001	0.017**	0.002	0.000	0.002	0.011
no. 1 kernel percentage	222.72	2725.42**	107.50	84.39	837.83*	616.44
total α-amino nitrogen	0.32	4.65*	0.72	9.36**	1.49**	0.26
conarachin	0.18	17.67**	0.58	3.34	7.65*	2.05
soluble carbohydrate	2.14	842.64**	28.96	41.04	68.51**	19.66
sucrose	102.75	2980.46**	285.33	189.93**	277.08**	137.84
glucose	0.001	0.035**	0.001	0.005	0.001	0.001
color						
unskinned kernels						
L value	4.82	95.22**	6.89	38.41**	4.89	18.07
a value	0.15	0.24	12.05	4.23**	0.76	5.28
b value	1.05	4.64	3.35	1.07*	0.59	1.58
deskinned kernels						
L value	6.05	257.57**	22.06	12.78*	9.51	21.98
a value	2.70	73.96**	2.82	4.79*	1.66	7.60
b value	0.088	6.56	3.13	2.94*	1.08	3.99

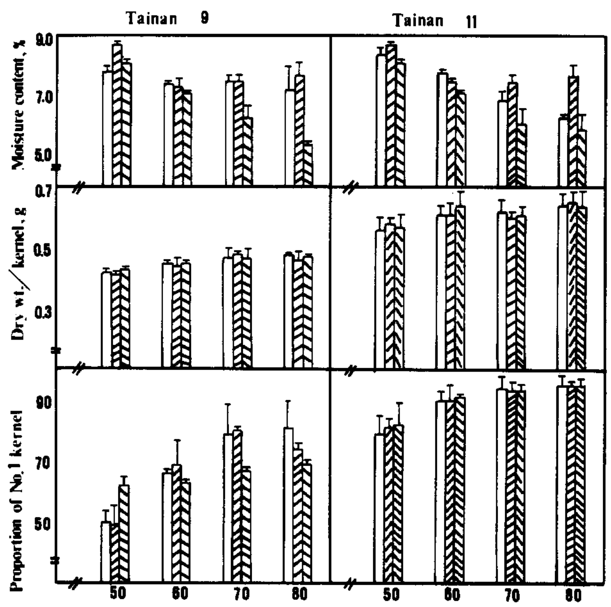

Figure 1. Moisture contents, kernel size (dry weight per kernel), and weight proportion of sized Tainan no. 9 and no. 11 peanut kernels at various maturity stages which were subjected to various drying practices: (□) removed from vine before sun-drying; (▨) not removed from vine before sun-drying; (▧) oven-dried.

et al., 1991a) to prepare fat-free peanut meals. The nitrogen content in the meals was determined by the Kjeldahl method (AOAC, 1985) to measure the crude protein contents. Methanol–chloroform–water (MCW) extracts were prepared for determinations of total α-amino nitrogen, soluble carbohydrate, glucose, and sucrose contents according to the procedures reported by Free (1963), Young et al. (1974), Rodriguez et al. (1989), and Chiou et al. (1991a,b), respectively.

For conarachin determination, defatted peanut meal containing 75 mg of protein was homoginized, extracted, and sodium sulfate fractionated, according to the procedure reported by Chiou et al. (1991b). The conarachins were quantitated by the Lowry method (Lowry et al., 1951) using bovine serum albumin as the standard, and subjected to SDS-PAGE analysis following the procedure of Chiou et al. (1991b).

Peanut Roasting. Peanut kernels of similar size (10 kernels from each treatment) were moisture equilibrated in a desiccator containing a saturated NaCl solution (Aw 0.756, 25 °C) without light exposure for 1 month at room temperature. The kernels were roasted in a forced-air oven at 150 °C for 20 min. After roasting, kernels were cooled in a desiccator with silica gel as the desiccant and subjected to color measurement using a color difference meter (Nippon Denshoku 80 color difference meter, Tokyo, Japan). After deskinning by hand, the color of the deskinned roasted kernels was measured by the same method.

Statistics. Two cultivars of peanuts, four harvest dates, and three drying practices were evaluated. Three replications were done. Means of determination with standard deviations are reported. ANOVA was applied to analyze the variance of the data among treatments.

RESULTS AND DISCUSSION

Moisture Contents, Kernel Size, and Distribution. Moisture contents, average dry kernel weight and total weight percentage of U.S. no. 1 kernels in lots of dried Tainan no. 9 and no. 11 peanut kernels are shown in Figure 1. Moisture contents varied significantly ($P < 0.01$) with harvest date (maturity) and drying practice (Tables I and II). On a dry solid weight basis, the average kernel size increased significantly ($P < 0.01$) with increase of maturity. In comparison, Tainan no. 11 kernel size was bigger than that of Tainan no. 9. On a total weight basis of each lot of harvested and cured kernels (moisture content was included), the proportion of the no. 1 kernels (weight percentage) increased significantly ($P < 0.05$) with increase of maturity. At each maturity stage, the average kernel size and weight percentage of the sized no. 1 kernels were not influenced by drying practice.

Total α-Amino Nitrogen and Conarachin Contents. Changes in total α-amino nitrogen and conarachin contents in kernels at various maturity stages which were subjected to various drying practices are presented in Figure 2 and Tables I and II. Variation in total α-amino nitrogen was significantly related to maturity stage ($P < 0.05$) and drying practice ($P < 0.01$). Except for oven-dried Tainan no. 9 kernels, the total α-amino nitrogen contents generally decreased with an increase in maturity. This is in agreement with observations by Young et al. (1974), Basha et al. (1976), and Rodriguez et al. (1989) that more free amino acids and total α-amino nitrogen exist in immature kernels than in mature kernels. Therefore, in this study, the maturation status of the sized kernels (U.S. no. 1 shelled Spanish) obtained at different times after flowering were disimilar. In other words, maturity increased with an increase in time elapsed between flowering and harvest. When a comparison was made between drying practices at each maturity stage, the highest α-amino nitrogen content was observed in kernels obtained from pods which remained on the vine during drying on a cement slab for 6 days. In the case of oven-dried Tainan no. 9 kernels, the α-amino nitrogen content increased at 60 days, decreased at 70 days, and increased again at 80 days after flowering.

Table II. ANOVA of Peanut Kernel Composition and Roasted Kernel Color of Tainan No. 11 Peanut Kernels at Various Maturity Stages Which Were Subjected to Various Drying Practices

	source of variance (degrees of freedom)					
items	block (2)	harvest date (3)	main error (6)	drying practice (2)	interaction (6)	minor error (16)
moisture content	0.41	16.15**	0.30	6.59**	3.16**	1.76
kernel weight	0.011	0.067**	0.015	0.001	0.004	0.013
no. 1 kernel percentage	57.39	1031.22*	313.28	2.39	19.61	277.33
total α-amino nitrogen	0.65	7.35*	0.94	3.15**	0.30	0.31
conarachin	0.11	1.41	0.55	3.31*	2.25	0.85
soluble carbohydrate	71.75	493.69	50.59	19.72	17.04	21.01
sucrose	74.35	2586.36**	360.35	118.08	90.22	472.39
glucose	0.001	0.026**	0.002	0.000	0.002	0.001
color						
unskinned kernels						
L value	0.60	42.37	56.42	91.34**	14.85	26.50
a value	0.33	8.29	4.39	1.33	4.62	4.30
b value	0.65	2.40	9.19	18.01**	2.21	4.53
deskinned kernels						
L value	6.63	114.93	71.81	48.07**	10.27	25.69
a value	1.59	24.92	23.59	50.07**	8.58	14.64
b value	2.63	2.65	13.08	33.11**	3.95	4.17

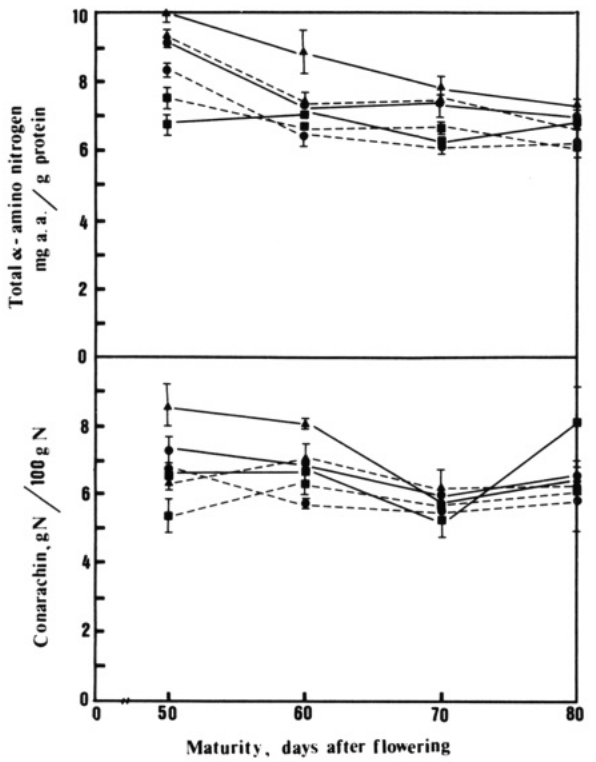

Figure 2. Total α-amino nitrogen and conarachin contents in sized Tainan no. 9 and no. 11 peanut kernels at various maturity stages which were subjected to various drying practices: (—) Tainan no. 9; (- - -) Tainan no. 11; (▲) removed from vine before sun-drying; (●) not removed from vine before sun-drying; (■) oven-dried.

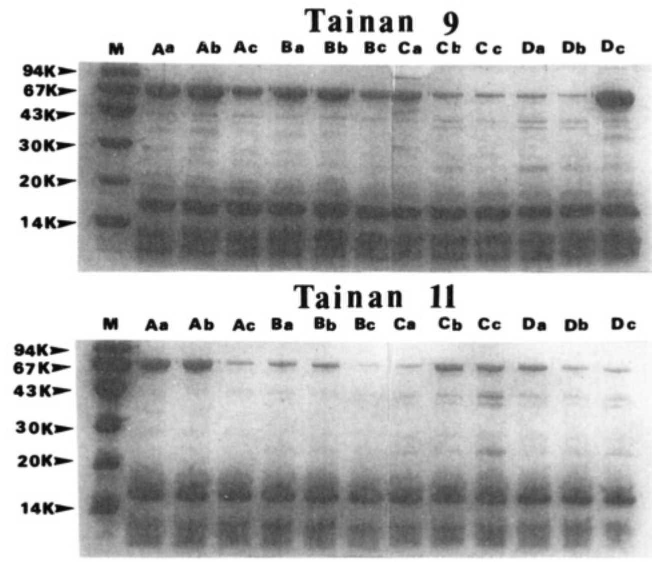

Figure 3. SDS-PAGE analyses of conarachin patterns extracted from sized Tainan no. 9 and no. 11 peanut kernels at various maturity stages which were subjected to various drying practices; M, protein markers; A, 50, B, 60, C, 70, D, 80 days between flowering and harvest date; a, removed from vine before sun-drying; b, not removed from vine before sun-drying; c, oven-dried.

Variation in conarachin content in Tainan no. 9 kernels was significantly related to maturity stage (Tables I and II). However, for Tainan no. 11 kernels, conarachin content was significantly related to drying practice. In general, conarachin contents decreased significantly between 60 and 70 days and increased slightly at 80 days after flowering. However, in the case of oven-dried Tainan no. 9 kernels, a significant increase of conarachin content occurred between 70 and 80 days after flowering. When conarachins were analyzed by SDS-PAGE (Figure 3), the band intensity of the high molecular subunit (ca. 67 000 Da) was closely correlated with the increased concentration shown in Figure 2. This also indicates that this subunit was significantly dependent upon harvest date and drying practice. In addition to the fact that this subunit is comparatively sensitive to heat treatment during peanut processing (Chiou, 1990), its original content in peanut kernels and significance in flavor performance during roasting is of interest and concern to the peanut industry.

Glucose, Sucrose, and Total Carbohydrate Contents. Changes in glucose, sucrose, and total carbohydrate contents in peanut kernels at various maturity stages which were subjected to various drying practices are shown in Figure 4. In general, glucose, sucrose, and carbohydrate contents decreased with an increase in kernel maturity. This is in agreement with reports by Basha et al. (1976) and Amaya-Farfan et al. (1978), who observed that glucose and total carbohydrate contents decrease as peanut seeds mature.

Rodriguez et al. (1989) classified peanut pods into five maturity stages and observed that soluble carbohydrate content decreases with an increase in maturity up to the fourth stage and then increases again at the fifth stage. However, Pattee et al. (1974) reported that sugar and starch contents increase in peanut seeds as maturity progresses. From a statistical viewpoint (Table I and II), for Tainan no. 9 kernels, variation in glucose and total carbohydrate

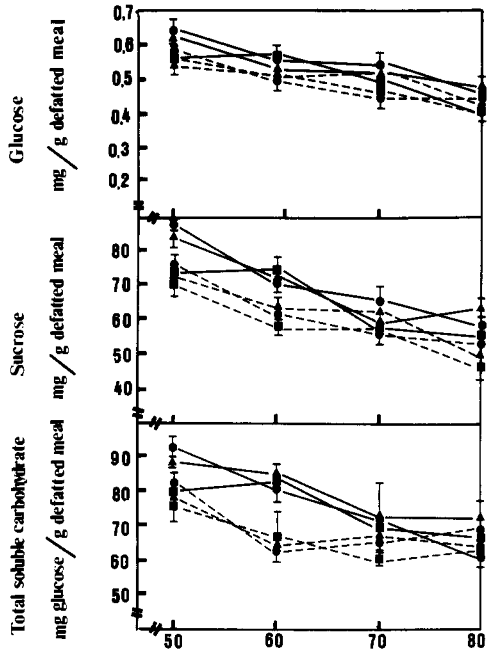

Figure 4. Total soluble carbohydrate, sucrose, and glucose contents in sized Tainan no. 9 and no. 11 peanut kernels at various maturity stages which were subjected to various drying practices; (—) Tainan no. 9; (- - -) Tainan no. 11; (▲) removed from vine before sun-drying; (●) not removed from vine before sun-drying; (■) oven-dried.

contents was significantly dependent on the maturity stage. However, sucrose contents were significantly related to both harvest date and drying practice. For Tainan no. 11 kernels, only glucose and sucrose contents were significantly related to harvest date.

Color of Peanut Kernels after Roasting. After moisture equilibration, peanut kernels were roasted at 150 °C for 20 min, and color values (L, a, and b) were determined (Figure 5). For unskinned kernels, L, a, and b values increased slightly with increase of maturity. The highest L and b values were observed in unskinned oven-dried kernels. For deskinned kernels, L values increased and yet a and b values decreased slightly with an increase of maturity. This is in agreement with Sanders et al. (1989b), who roasted peanut kernels of various maturity classes for the same time and showed that Hunter L values increase as maturity increases.

Changes of L and b values of unskinned kernels after roasting were significantly ($P < 0.01$) influenced by the drying practice but not significantly influenced by the stage of maturity (Tables I and II). For deskinned kernels, changes of L, a, and b values are significantly dependent on drying practices but were not significantly influenced by maturity. Since kernel size was similar at each maturity level (Figure 1) and the Aw of kernels was 0.75, differences in color performance after roasting resulted mainly from the differences in chemical composition resulting from drying practices (Figures 2–4).

From a basic peanut science viewpoint, an interacting effect of peanut maturity and drying practice on chemical composition and color performance during roasting of the sized peanut kernels has been demonstrated. Based on the fact that average maturity level of the sized kernel lots increased with harvest date, it is unlikely to obtain lots of kernels with the same maturity status simply by using a size-grading operation. From a practical viewpoint, peanuts harvested at least at 70 days after flowering for both

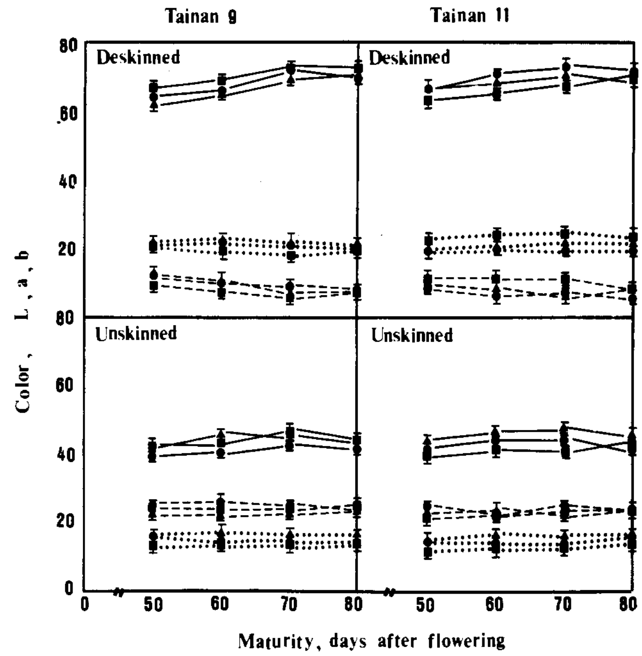

Figure 5. Color measurements of unskinned and deskinned roasted Tainan no. 9 and no. 11 peanut kernels at various maturity stages which were subjected to various drying practices: (▲) removed from vine before sun-drying; (●) not removed from vine before sun-drying; (■) oven-dried; (—) L value; (- - -) a value; (···) b value.

peanut cultivars tested in this study would be suggested in terms of the observation that increases of the proportion and average kernel weight of the sized U.S. no. 1 kernels and chemical changes varied significantly from 50 to 70 and then varied in a limited range from 70 to 80 of harvest dates. On the other hand, application of the effect of dry practices to benefit the quality of roasted kernels will depend upon flexibility in harvesting and processing practices as well as economic considerations.

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